A MANUAL OF
PRACTICAL TROPICAL SANITATION

This book is copyright. It may not be reproduced by any means in whole or in part without permission. Application with regard to copyright should be addressed to the Publishers.

A MANUAL OF PRACTICAL TROPICAL SANITATION

By

J BALFOUR KIRK, C M G ,
M.B., Ch.B., F R.C.P., D.P.H., D T M. & H
Formerly Director Medical and Health Department, Mauritius
Director Medical Services Gold Coast



LONDON
BAILLIÈRE TINDALL AND COX
7 AND 8 HENRIETTA STREET W C.2
1949

To

A. C. LABAUVE D'ARIFAT

M.R.C.S. L.R.C.P.,

IN FRIENDSHIP

PRINTED IN GREAT BRITAIN

PREFACE TO SECOND EDITION

THIS book was originally published in 1937 and was meant principally as a handbook for the use of persons following a course of instruction in Sanitary Inspector's work in the tropics. At the same time it was hoped that the definition of technical terms and the use of plain language would make its contents intelligible to others whose work brings them into contact with the problems affecting the health of labour forces on mines, estates and other enterprises situated in places where technical aid may not be readily available. A knowledge of the contents of this book will at least give a manager some indication of what remedial action may be taken and will indicate to him the ways in which many of the diseases likely to affect the efficiency of a labour force may be prevented.

The exhaustion of the first edition has provided the opportunity of bringing the subject matter up to date.

J BALFOUR KIRK.

LONDON
March 1949

CONTENTS

CHAP		PAGE
I	The Cell	1
II	The Anatomy and Elementary Physiology of the Human Body	16
III	Communicable Diseases. Group I	34
IV	Worm Infections Spread through the Excreta	51
V	Communicable Diseases: Group II	63
VI	Elementary Entomology	76
VII	The Insect borne Diseases	92
VIII	Miscellaneous Communicable Diseases	120
IX	Disinfection	138
X	Housing	160
XI	Food	172
XII	Food (*continued*) Abattoirs, etc	193
XIII	Milk	203
XIV	Water and Water Supplies	216
XV	The Collection and Disposal of Sewage	237
XVI	The Collection and Disposal of Refuse	257
XVII	Laundries	267
XVIII	Schools	269
XIX	Village Sanitation	270
XX	Miscellaneous Data	273
	Index	279

CHAPTER I

THE CELL

IF any part of a plant or animal is suitably prepared and examined under the microscope at a magnification of from two to four hundred diameters it is seen to consist of a number of units which may be of different shape and size but are just as clearly its component units as bricks are the components of a brick wall. These units are known as cells, and as the different parts of the human body are composed of cells of various kinds it is necessary to have some idea of what constitutes a cell and what the cell does.

The first point to be grasped is that each cell of the body is alive, and though most cells do not usually move about within the body they perform work. For this work they need energy which they obtain from the food. As a result of their work part of their substance becomes worn out, and the products of this deterioration have to be removed and damaged constituents replaced.

Though the life of the individual cells of the animal body depends upon the life of the animal, the cells have individual existence and remain alive for some time after the animal itself is dead. What ultimately kills them is the breakdown of the mechanism for the removal of waste products and the failure of the supply of foodstuffs to them. When artificial arrangements can be made for the removal of their waste products and for their nutriment, certain cells can be kept alive in the laboratory and produce many generations long after the body from which they originally came has decayed and disappeared.

Though the bodies of all animals and plants that we can see are composed of myriads of living cells of diverse shapes, sizes and functions, there is a vast number of animals and plants enjoying an independent existence though invisible to the naked eye, which consist only of one cell. Our knowledge

A*

of these small bodies, known to science as micro-organisms, dates from the discovery of the art of making lenses which could magnify sufficiently to show them. Before such lenses were made the existence of this huge and important kingdom of living creatures was never suspected. At first only the larger members of it were discovered but as lenses improved and their magnifying power increased more and more of these little animals were discovered, studied and described until to-day their study forms a most important branch of medical and veterinary science.

An animal which consists of only one cell is known as a unicellular animal. One does not usually apply the term animal to such a small creature, but the term organism. A common unicellular organism is one known as the *amœba* and a study of it gives one a good idea of the structure of a cell.

The amœba (plural, amœbæ) is found in stagnant water all over the world. For its study a compound microscope is required which can magnify it some hundred times. If a drop of water containing amœbæ is placed on a glass microscope slide and examined in the appropriate manner under the microscope the amœbæ appear as round objects of a clear jelly like material which may be seen to contain small particles in its substance. If an amœba is watched for some time the particles may be seen to move inside the animal, and as the eye becomes accustomed to the appearance of the clear substance of which the amœba consists, spherical cavities containing particles may be made out. These are known to be digestive cavities where the food ingested by the amœba is digested. After a time, when the effect of the disturbance of the manipulations in making the preparation has passed off, the amœbæ may be seen to flatten out and become irregular in shape. When they do this the body substance is seen to consist of two kinds of material a rather opaque granular substance which accumulates in the middle of the animal and a clear transparent substance extending all round the edges. These are merely different physical states of the same substance to which the name of *protoplasm* has been given. The substance most resembling protoplasm with which we are familiar is the white of an egg A little later the amœba will be seen to send out from its body a broad stumpy feeler which may be drawn in again. But frequently it looks as though the feeler were extended and the rest of the protoplasm were flowing into it and we

realise that this is the way in which the amœba moves This rolling type of movement is very characteristic of many unicellular organisms and it is known as *amœboid movement.* What have been termed broad feelers are known scientifically as *pseudopodia*, a compound word derived from two Greek words meaning false feet.

The amœba uses pseudopodia not only as a means of moving over the surface of objects in the water but also as organs for the trapping of minute particles of food. Pseudopodia of this kind are usually more slender than the pseudopodia used in movement. The food may be ingested by the animal withdrawing into its body the pseudopodium to which the food particle is sticking or the pseudopodium may enlarge and the protoplasm of the body flow into it and eventually surround the particle.

By special methods of examination another component of the amœba may be demonstrated. It is a small, usually spherical, body know as the *nucleus*. The nucleus is essential to the life of the amœba. If a piece of protoplasm is cut off from the amœba in such a way as to separate it from nuclear material, that piece dies but the part of the cell containing the nucleus can repair the damage so long as the nucleus suffered no injury in the operation (Fig. 1 1).

The reproduction of amœbæ is brought about by the animal dividing into two parts, which are known as daughter amœbæ At the beginning of this process the nucleus divides into two parts after a complicated series of changes. Each part then moves to the edge of the body of the animal which has become oval in shape—one nuclear part at each end. Then, in the middle of the body a constriction appears which bites deeper into the substance until the two halves become separated. Each now takes up an independent existence as another amœba. This method of reproduction is known as reproduction by transverse fission.

From the above description it is seen that the essential parts of a cell are the protoplasm and nucleus, and a cell may be defined as a mass of protoplasm containing a nucleus. This definition describes the fundamental features of every animal or vegetable cell, though the form and the functions of different cells may vary enormously

Our necessarily short description of the amœba illustrates also the properties of any living cell. It is irritable, that is, it

can respond to stimulation by activity it can grow and can reproduce.

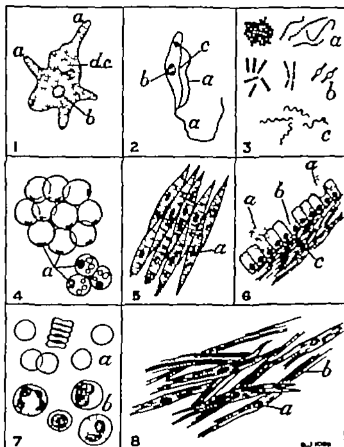


FIG. 1

1. An amoeba.
   = pseudopodium.
   b = nucleus.
   d.c. = digestive cavity
2. A trypanosome.
   = flagellum.
   b = nucleus.
   = undulating membrane
3. Bacteria.
   a = cocci.
   b = bacilli.
   = spirilla.
4. Fat cells.
   = nucleus.
5. Muscle cells.
   × nucleus.
6. A mucous membrane shewing mucus-secreting cells.
   = mucus.
   b = spent mucus-secreting cell.
   = connective tissue.
7. Cells of the blood.
   a = erythrocytes.
   b = leucocytes.
8. Elongated cells and fibres constituting connective tissue.
   a = nucleus.
   b = fibrils.

The unicellular animal has the most primitive structure we know But though it is composed only of one cell it may possess

a number of miniature organs. To protect itself it may form a horny shell or tough skin as organs of locomotion it may develop a long filament of elastic substance known as a flagellum, which by a lashing movement pulls the animal through the liquid in which it lives (Fig 1 2), or the outer part of the animal may grow short contractile hair like structures known as cilia, which by their rhythmical movement propel the animal through the medium much as the oars propel a rowing-boat through the water

From these unicellular animals known as protozoa, we can arrange in a series of groups animals whose bodies consist of numerous cells arranged in gradually increasing complexity until we arrive at the highly specialised tissues of the vertebrates. But all these animals originally begin as a single cell, the fertilised ovum. Multicellular animals are known as the *metazoa*

The metazoa are arranged in two series one, animals composed of groups of cells scattered without any definite bond of union in an overwhelming mass of intercellular substance. The sponges are of this type and this series are known as the *Porifera* The other series, the *Enterozoa* consists of animals which have developed a body wall composed of specialised cells together with mouth and well-defined digestive cavity

The Enterozoa are again arranged in two series. The one series includes animals like the polyps, sea anemones and jelly fishes (*Cœlenterata*) in which the cavity enclosed by the body-wall is the digestive cavity the other series, the *Cœlomata* includes animals whose body wall encloses a body-cavity or cœlom which has definite functions and is quite distinct from the digestive cavity which passes through it or is suspended from it. The Protozoa, Porifera and Enterozoa constitute three of the groups or *phyla* of the animal kingdom. The Cœlomata are also subdivided into numerous phyla, of which the most important from our point of view are the *Platyhelminthes* or parasitic flat worms, the *Nemathelminthes* or parasitic round worms, the *Arthropoda* or segmented animals with a firm outer skeleton (exo-skeleton) and jointed appendages, the *Mollusca* or soft-bodied unsegmented animals lik the snail and the oyster which are enveloped in mantle and shell, and the *Vertebrata* which possess a backbone and a skull though these may be very rudimentary

Modification of Cells

We have seen that the free living protozoa are provided with various organs for movement, or for the capture of food or of protection. The metazoan animals, however are much more complicated and the cells composing them become united into tissues and organs which have specialised work to do This specialised function becomes developed at the expense of other functions, and it exerts a profound influence on the form of the

can respond to stimulation by activity it can grow and can reproduce.

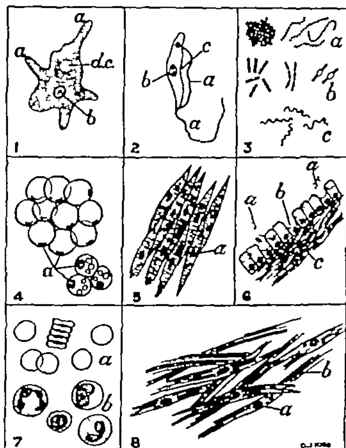


FIG. 1

1. An amoeba.
   = pseudopodium.
   b = nucleus.
   d.c. = digestive cavity
2. A trypanosome.
   = flagellum.
   b = nucleus.
   c = undulating membrane.
3. Bacteria.
   = cocci
   b = bacilli.
   = spirilla.
4 Fat cells.
   = nucleus.
5 Muscle cells.
   × nucleus.
6. A mucous membrane shewing mucus-secreting cells.
   = mucus.
   b = spent mucus-secreting cell.
   = connective tissue.
7 Cells of the blood.
   = erythrocytes.
   b = leucocytes.
8. Elongated cells and fibres constituting connective tissue.
   = nucleus.
   b = fibrils.

The unicellular animal has the most primitive structure we know But though it is composed only of one cell it may possess

a number of miniature organs. To protect itself it may form a horny shell or tough skin as organs of locomotion it may develop a long filament of elastic substance known as a flagellum, which by a lashing movement pulls the animal through the liquid in which it lives (Fig 1 2), or the outer part of the animal may grow short contractile hair-like structures known as cilia, which by their rhythmical movement propel the animal through the medium much as the oars propel a rowing boat through the water

From these unicellular animals known as protozoa, we can arrange in a series of groups animals whose bodies consist of numerous cells arranged in gradually increasing complexity until we arrive at the highly specialised tissues of the vertebrates. But all these animals originally begin as a single cell, the fertilised ovum. Multicellular animals are known as the *metazoa*

The metazoa are arranged in two series one, animals composed of groups of cells scattered without any definite bond of union in an overwhelming mass of intercellular substance. The sponges are of this type and this series are known as the *Porifera* The other series, the *Enterozoa* consists of animals which have developed a body wall composed of specialised cells together with mouth and well-defined digestive cavity

The Enterozoa are again arranged in two series. The one series includes animals like the polyps, sea anemones and jelly fishes (*Coelenterata*), in which the cavity enclosed by the body wall is th digestive cavity the other series, the *Coelomata*, includes animals whose body wall encloses body-cavity or coelom which has definite functions and is quite distinct from the digestive cavity which passes through it or is suspended from it. The Protozoa, Porifera and Enterozoa constitute three of the groups or *phyla* of the animal kingdom. The Coelomata are also subdivided into numerous phyla, of which the most important from our point of view are the *Platyhelminthes* or parasitic flat worms, the *Nemathelminthes* or parasitic round worms, the *Arthropoda* or segmented animals with firm uter skeleton (exo-skeleton) and jointed appendages, the *Mollusca* or soft bodied unsegmented animals like the snail and the oyster which are enveloped in a mantle and shell, and the *Vertebrata* which possess backbone and skull though these may be very rudimentary

Modification of Cells

We have seen that the free living protozoa are provided with various organs for movement, or for the capture of food or of protection. The metazoan animals, however are much more complicated and the cells composing them become united into tissues and organs which have specialised work to do. This specialised function becomes developed at the expense of other functions, and it exerts a profound influence on the form of the

cell. Thus certain cells in the tissues of animals are specialised for the storage of fat and their appearance is very different from the cells of muscular tissue, for instance, whose chief function is to do muscular work. The fat cell stores up fat in its substance to such an extent that the body of the cell becomes thinned out into a fine spherical membrane enclosing the fat droplet. The nucleus is also flattened (Fig 1 4) The muscle cell, on the other hand, develops the contractile substance to a great extent and elongates into a spindle-shaped body (Fig 1 5). The cells composing what are known as the connective tissues are flattened, lengthened, branching cells which secrete a clear substance in which they lie, through which run fibres manufactured by the cells which unite the whole mass into fine bands of tissue whose function it is to cover limit, or support the other cells of the body (Fig 1 8) In certain parts lime salts are deposited in such tissues and they become the bones of the body It is this development of specialised function which modifies the cells of the body into the many different forms they assume in the meta zoan animal.

Bacteria

The structure of the members of the vegetable kingdom varies as in those of the animal kingdom between unicellular plants and multicellular The unicellular plants have much importance in hygiene and it is necessary to know something about them.

The division of unicellular plants with which our work is most concerned is that known as the *bacteria*. These micro-organisms are very much smaller than most of the protozoa and, in fact, many of them form the food of protozoa. For their study they require special methods.

An important part of the study of bacteria is the provision of a suitable substance, known as a *medium* for their nutriment. The medium may be a liquid, a jelly or a solid. The appearance of the bacteria, their capacity for growth, and the products of their activity when grown on media of different composition are some of the characters used in classifying them.

Bacteria have importance in several ways. They are the main cause of what is known as the putrefaction of organic matter They and other lowly organisms closely related to them, are employed commercially in the manufacture of such

foodstuffs as cheeses, beer and vinegar Certain of them cause the spoiling of foodstuffs, e.g the "straw" taste of eggs, or even their putrefaction. A large group of them are responsible for what are known as the communicable diseases of man and animals. Others living in the soil have great importance in the nutrition of plants. We use still others for the purification of sewage.

Bacterial cells have three main forms, cylindrical, spherical or spiral. The cylindrical bacteria are known as *bacilli*, the spherical as *cocci* and the spiral as *spirilla* (Fig 1 3) Many bacteria are capable of independent movement because they are provided with flagella, just as several of the protozoa have these organs of locomotion.

One difference between the bacterial cell and that of the protozoa is the form which the nuclear material takes. In the protozoa the nuclear material has generally a definite form, but in the bacteria it is represented by small particles which may be demonstrated only by the employment of special technique.

Bacteria reproduce by *fission* The cell divides and becomes two daughter cells which quickly grow to resemble the parent. The rate of growth varies with the temperature and the material in which cell occurs. There are certain substances known as *antiseptics* which prevent the reproduction of bacteria. Others known as *disinfectants* kill the bacteria in the strengths employed.

The *pathogenic* bacteria, i.e. those causing disease, grow best at the temperature of the human body about 98·4 F or 37° C Their growth may be retarded by cold some may be killed by it, but there are others, such as the *Bact typhosum*, the cause of enteric or typhoid fever which can remain alive in the frozen state for many months. A temperature of more than 60 C. will kill most pathogenic bacteria if they are exposed to it for half an hour Thereafter a progressive rise in temperature kills in a progressively shorter time until at a temperature of 110° C. all bacteria are killed in a few seconds.

Pathogenic bacteria have become more or less adapted to the conditions of the interior of the animal body As a general rule, when they leave the body or if their presence and growth should result in the death of the animal, they ultimately disappear Certain of them may however remain in a grave for years unless special precautions are taken to prevent this. Some of the pathogenic bacteria are able to safeguard their existence by

developing round themselves a kind of thick skin. When they do this they become inactive and remain in a more or less passive state something like the inactivity seen in plant seeds. Such a bacterium is known as a *spore* and it is by spore formation that *these bacteria are able to live outside the body of animals.* Fortunately for the animal kingdom there are not many pathogenic bacteria which can become spores.

Bacteria cause disease not only in animals but in plants, though we are not greatly concerned with this aspect of them here.

Bacteria are not all pathogenic, as we have already seen. Many of them, although parasitic in the animal body have *now become essential to the life of the animal in which they* live. In our own intestinal canal we maintain a large and complicated group of bacteria which live upon the food we eat and convert its constituents into other substances more easily acted upon by the digestive juices. As the foodstuffs pass slowly down the large intestine the myriads of bacteria which they contain die, so that the fæces consist of the undigested residue of food, waste solids from the body-cells, countless dead bacteria and a number of intestinal bacteria which have escaped death.

Rickettsia

The rickettsias are small organisms resembling bacteria. Their size lies somewhere between that of the smallest bacteria and the filter passing viruses. They have the peculiarity that they seem to be confined to living cells, and do not appear to be able to increase in numbers outside living cells.

Rickettsias are found in the cells of the alimentary tract of *certain insects (lice) and other arthropods (ticks and mites)*

Infection of man takes place through the bite of the infected insect. The common rickettsial diseases of man are typhus fever trench fever Japanese river fever Q fever Rocky Mountain spotted fever and Rickettsialpox.

The Filter passing Viruses

Another group of organisms, even smaller in size than the rickettsia, though known now to be living organisms, are the viruses, sometimes called the filter passing viruses. The latter *name has been given to them because they can pass through the*

pores of filters which are so fine as to prevent the passage of bacteria through them.

There is not much known about the viruses though our knowledge of those which cause disease is gradually accumulating. We know that they are living organisms, and that they can increase in numbers in a favourable medium. Some of them are virulent to the human body and their invasion of the body may result in the so-called virus diseases of which the best known are rabies, yellow fever smallpox and chicken pox, sand fly fever dengue fever and influenza. The body can develop immunity against most virus infections, and we have means of producing active immunity against them which will be indicated when mentioning the various diseases caused by them.

Disease

The healthy living body tends to keep healthy and its health is characterised by the harmonious working of all its parts for the benefit of the whole. Nevertheless, in the ordinary course of active existence conditions which are injurious to tissues and cells are met with. Our bodies have been able to survive in the world because they have the power of adaptability which is of modifying their structure, and sometimes their behaviour in response to conditions which might otherwise destroy them. Thus the highly specialised tissues of which the body is composed are protected from mechanical damage by the development of certain cells in the form of the skin, which presents a tough though pliant surface to the exterior Other tissues become bony and serve to support and protect the softer tissues enfolding them or enclosed by them. The provision of fluid to the body-cells is made by the circulation of the blood and the maintenance of a temperature most suited to their activity is effected by a delicate and complicated mechanism for regulating the heat evolved as the result of cellular work. The mechanism is so finely adjusted that the temperature of the vital parts of the body is kept very nearly constant, no matter how much the external temperature may vary within reasonable limits.

Disease or ill health are evidence of a defective working of the body or of some part of it. The bodily activities are so intimately adjusted to one another that the defective working of a part generally affects the working of the whole sooner or later We

are still ignorant of the cause of much of the ill health or disease from which we suffer We do not know for instance, what affects the mechanism regulating the growth of tissues, and therefore cannot account for the appearance of tumours in certain parts of the body There are other conditions in which certain organs whose function it is to pour into the blood substances which regulate the working of others, begin to function defectively and so affect the working or growth of other organs or of the body as a whole. An example of this is seen when the thyroid gland fails to develop in children and physical and mental development are grossly interfered with.

But there is a large group of diseases which we know are caused by the invasion of the body by bacteria or other micro-organisms such as the protozoa. The interesting thing about them is that each kind of micro-organism, be it a bacterium or a protozoon, evokes from the body a response which is shown in pretty much the same way whenever bacteria or protozoa belonging to that species invade the tissues. It is this particular reaction of the body to invasion by micro-organisms which gives to what we call the communicable diseases their distinctive character enabling them to be recognised and the one differentiated from the other Thus, invasion of the body by the typhoid bacillus is followed by certain bodily changes which we recognise as typhoid fever and though these changes may vary in severity in different patients, and though the result may be death or recovery of the patient, these changes all occur in approximately the same order and in the same tissues in *all* patients, irrespective of whether they were infected from the same source or whether they were infected in different parts of the world. That is to say though details may vary there is a strong family resemblance in all cases of typhoid fever occurring all over the world. The same *holds good for the response of the human body to invasions* by other pathogenic organisms, so that, knowing what these responses are, and the way in which they are manifested, e.g skin rashes digestive disturbance discharges interference with particular organs, and the disturbance of the heat regulating mechanism leading to abnormally high or low temperatures, we can deduce what organism is at work, even though we may not be able to obtain it from the patient.

The Body's Means of Defence.—The means of defence against the action of harmful organisms adopted by the multicellular

animal are many and complicated. Here it will suffice to mention them in general terms.

We have seen that so far as the outside of the body is concerned, the cells of the metazoan animal arrange themselves not unlike a brick wall to form the tissue known as the skin (p 32) and the outermost cells of the wall become filled with granules of a horny waterproof material known as keratin. This acts as a tough flexible protective layer for the tissues underneath and so long as it is not damaged it keeps out bacteria. The inner parts of the body which communicate with the exterior such as the trachea and the intestinal canal, are protected by being covered with a film of *mucus* a gummy secretion produced by what are known as *mucus secreting cells* which are found interspersed among the other cells lining those tubes (Fig 1 6). Mucus tends to entangle bacteria, and it also acts as a mild antiseptic by reason of certain substances which it contains. Infection by certain bacteria in the respiratory and alimentary tracts gives rise to a great secretion of mucus which can be seen in the nose running of the familiar cold in the head, or in the mucous discharges from the bowel of a patient suffering from dysentery. Moreover the saliva and the gastric juice have a disinfectant action and kill many of the bacteria ingested with the food.

Within the body itself the cells can produce what are known as *antibodies* which circulate in the blood and affect bacteria and their poisonous products in several ways, all tending to render them harmless. And there are certain cells, notably the white corpuscles of the blood and what are known as the endothelial cells, which can actually move about in the body and devour not only the damaged cells of the tissues but also pathogenic bacteria which may gain entrance.

Bacterial Means of Offence —Invasion of the body by bacteria may be compared with the invasion of a country by a hostile army. There will be casualties on both sides. Many bacteria will die in the process in dying they will make the way easier for their successors, either by overcoming the resistance of the cells at the point of entry or by the actual death of these cells. On the other hand, there will be some disorganisation of the body's function while the body is mobilising its resources to overcome the invasion. The period required for mobilisation varies sometimes it is short sometimes long, and the patient himself is not usually conscious of it. This period is known as

the *incubation period* of the disease. Both sides, the invading microbes and the body are getting ready for the fight. The fight itself creates all the ordered disorganisation we know as disease, and it may last for a longer or shorter time according to the relative strength of the bacterial invaders and the defensive mechanism of the body In the acute infectious diseases the result is generally clear cut, either the patient dies or recovers completely but in some cases irreparable damage may be done to certain structures and permanent disability such as deafness, impaired vision, or localised paralysis may follow

The means which the bacteria have of effecting an entrance into the tissues of the living body are almost as varied as the means of defence possessed by the tissues themselves. The common paths of infection are cuts or scratches of the body's surfaces—the skin or the mucous membranes lining the alimentary and respiratory tracts. Inhalation may also cause an infection of the respiratory tract, as ingestion may affect the alimentary canal. It is interesting to note that individual organisms show a certain choice in the tissues which they normally attack. The diphtheria bacillus shows a preference for mucous membranes, especially those of the pharynx the organisms causing dysentery and typhoid fever those of the intestinal canal, the tubercle bacillus, the lungs and the leprosy bacillus, the skin and nerves

Pathogenic bacteria have a property known as *virulence*, which may be defined as the ability of bacteria or other micro-organisms to penetrate and establish themselves in living tissues. What governs virulence is at present unknown. Another property displayed by certain bacteria is their ability to produce poisonous substances known as *toxins* which dissolve in the lymph and are carried in it to distant parts of the body where they concentrate on certain tissues and eventually kill them. Examples of toxins of this kind are given by the diphtheria bacillus whose toxin acts especially upon the nerves, and the tetanus bacillus whose toxin acts on the spinal cord. The ability to produce toxin is known as *toxicity* Note that it is different from virulence. A toxin which is given off from living bacteria is known as an *exo-toxin* one which only becomes liberated after bacteria die and disintegrate is known as an *endo-toxin*.

Immunity.—It has been found that when a patient recovers from one of the bacterial or virus diseases he may again be exposed to infection and yet not get a second attack. He is said

to be immune to that particular disease or to be in a state of immunity to it for the time being This is an old observation. In the eighteenth century when smallpox was very common in England, advertisements for servants used to state that preference would be given to applicants who had already had the small pox, because even then it had been noted that persons seldom suffered from smallpox twice.

The duration of the immunity developed by the human being as the result of an attack of disease is fairly constant for each disease. The immunity resulting from a common cold is short that arising from diphtheria is considerably longer typhoid fever and smallpox longer still while certain diseases confer an immunity which practically lasts the person's lifetime, e.g measles mumps, yellow fever and whooping-cough.

The immune state in an animal is shown by the presence in the tissue fluids of that animal (the blood and lymph) of substances known as *antibodies* The growth of antibodies in an animal's tissues may be demonstrated in the following way

If the diphtheria bacillus is grown in broth for a certain time and the broth is then separated from the bacteria by filtration, it is found that the broth contains a substance which kills animals by paralysis when a certain quantity of it is injected under the skin. This poison is known as the diphtheria toxin. Now if a quantity of diphtheria toxin is obtained and is injected into a healthy animal, such as the horse in a series of doses at about ten days interval, beginning with a harmless dose and gradually increasing the dose with each injection, it is found that at the end of some three months one can inject without ill effect a dose which, had it been injected at the beginning of the experiment, would have killed the horse outright. Therefore the horse has been able, during the time taken by the injections to develop some substance which rendered the toxin harmless. It can be demonstrated that this substance, known as diphtheria antitoxin, occurs in the blood serum (p 20) of the horse. A serum which has developed an antibody in this way is known as an *immune serum*

The antibody acts not only in the body of the immunised animal but also when it is withdrawn from it. If a quantity of immune serum is mixed with a quantity of its corresponding toxin and the mixture is allowed to remain for some time, it will be found that a much larger dose of the mixture can be injected into a susceptible animal without ill effect than if the dose were

the *incubation period* of the disease. Both sides, the invading microbes and the body are getting ready for the fight. The fight itself creates all the ordered disorganisation we know as disease and it may last for a longer or shorter time according to the relative strength of the bacterial invaders and the defensive mechanism of the body In the acute infectious diseases the result is generally clear cut, either the patient dies or recovers completely but in some cases irreparable damage may be done to certain structures and permanent disability such as deafness, impaired vision, or localised paralysis may follow

The means which the bacteria have of effecting an entrance into the tissues of the living body are almost as varied as the means of defence possessed by the tissues themselves. The common paths of infection are cuts or scratches of the body's surfaces—the skin or the mucous membranes lining the alimentary and respiratory tracts. Inhalation may also cause an infection of the respiratory tract, as ingestion may affect the alimentary canal. It is interesting to note that individual organisms show a certain choice in the tissues which they normally attack. The diphtheria bacillus shows a preference for mucous membranes, especially those of the pharynx the organisms causing dysentery and typhoid fever those of the intestinal canal, the tubercle bacillus, the lungs and the leprosy bacillus, the skin and nerves

Pathogenic bacteria have a property known as *virulence*, which may be defined as the ability of bacteria or other micro-organisms to penetrate and establish themselves in living tissues. What governs virulence is at present unknown. Another property displayed by certain bacteria is their ability to produce poisonous substances known as *toxins* which dissolve in the lymph and are carried in it to distant parts of the body where they concentrate on certain tissues and eventually kill them. Examples of toxins of this kind are given by the diphtheria bacillus whose toxin acts especially upon the nerves, and the tetanus bacillus whose toxin acts on the spinal cord. The ability to produce toxin is known as *toxicity* Note that it is different from virulence. A toxin which is given off from living bacteria is known as an *exo-toxin* one which only becomes liberated after bacteria die and disintegrate is known as an *endo-toxin.*

Immunity—It has been found that when a patient recovers from one of the bacterial or virus diseases, he may again be exposed to infection and yet not get a second attack. He is said

to be immune to that particular disease or to be in a state of immunity to it for the time being This is an old observation. In the eighteenth century when smallpox was very common in England, advertisements for servants used to state that preference would be given to applicants who had already had the smallpox, because even then it had been noted that persons seldom suffered from smallpox twice.

The duration of the immunity developed by the human being as the result of an attack of disease is fairly constant for each disease. The immunity resulting from a common cold is short that arising from diphtheria is considerably longer typhoid fever and smallpox longer still while certain diseases confer an immunity which practically lasts the person's lifetime, e.g measles mumps, yellow fever and whooping-cough.

The immune state in an animal is shown by the presence in the tissue fluids of that animal (the blood and lymph) of substances known as *antibodies* The growth of antibodies in an animal's tissues may be demonstrated in the following way

If the diphtheria bacillus is grown in broth for a certain time and the broth is then separated from the bacteria by filtration, it is found that the broth contains a substance which kills animals by paralysis when a certain quantity of it is injected under the skin This poison is known as the diphtheria toxin. Now if a quantity of diphtheria toxin is obtained and is injected into a healthy animal, such as the horse, in a series of doses at about ten days interval, beginning with a harmless dose and gradually increasing the dose with each injection, it is found that at the end of some *three months* one can inject without ill effect a dose which, had it been injected at the beginning of the experiment, would have killed the horse outright. Therefore the horse has been able, during the time taken by the injections, to develop some substance which rendered the toxin harmless. It can be demonstrated *that this substance, known as diphtheria antitoxin, occurs* in the blood serum (p 20) of the horse. A serum which has developed an antibody in this way is known as an *immune serum.*

The antibody acts not only in the body of the immunised animal but also when it is withdrawn from it. If a quantity of immune serum is mixed with a quantity of its corresponding toxin and the mixture is allowed to remain for some time it will be found that a much larger dose of the mixture can be injected into a susceptible animal without ill effect than if the dose were

merely toxin diluted with an inert diluent like saline solution. The animal so protected is said to be *passively immunised* against the toxin, and the immunity so conferred on it is known as *passive immunity* The immunity acquired by an animal as a result of the injection of pure toxin is known as *active immunity* because the tissues of the animal themselves produced the anti body by means of their own activity

Much the same kind of thing happens when actual bacteria are injected into susceptible animals. In this case the bacteria are usually killed before being injected, so that they cannot grow in the tissues of the animal and thus interfere with the result. It is found that the same immunising effect occurs with killed bacteria as would happen if the bacteria were alive, and the protection thus given is effective against infection by living bacteria.

The serum of an animal immunised against a bacterial toxin is known as an *anti toxic serum*, or shortly an *anti toxin*. The two in common use are diphtheria and tetanus anti-toxin. The serum of an animal immunised against the bacteria themselves is known as an *anti-bacterial serum* and those in common use are anti-typhoid serum, anti-cholera serum, anti plague, anti pneu mococcal, anti-streptococcal and anti meningococcal sera. In preparing the anti bacterial sera the injections of the animal are begun with dead bacteria, and after the animal has become sufficiently immunised, they are continued with living bacteria.

In public health work we make use of sera in two ways. The anti toxic sera are used to confer on the patient a passive immun ity to the toxin until he has had time to develop his own active immunity It is also used for persons who have been exposed to the disease (contacts) in order to fortify their tissues against attack by the toxins should they become infected.

The anti bacterial sera are used differently They are not usually given preventively except in emergency They are administered to a patient to reinforce his own immunity In the case of contacts we generally promote active immunity by injecting subcutaneously measured doses of killed bacteria at stated intervals of time. The preparation of dead bacteria used for this purpose is known as a *vaccine*.

It should be noted that antibodies are strictly specific. Diph theria anti-toxin will neutralise only diphtheria toxin It has no effect on tetanus toxin. Similarly an anti plague serum may

help to immunise a patient against plague, but it has no immunising effect in cholera or any other disease.

Immunity produced artificially in the way above described is not usually permanent, and when persons live in an area where a particular disease is endemic it is advisable to repeat the immunising treatment periodically

Our admiration for the ingenuity of our race should not blind us to the fact that its survival is probably due to the fact that a natural process of immunisation is continually going on in our bodies. It is reasonable to suppose that a certain number of bacteria are necessary to produce disease. If fewer than this number gain entrance to the tissues they are probably destroyed, and in destroying them the body acquires an immunity in pretty much the same way as the experimental animal or the inoculated contact, but only at a much slower and more gradual rate. This is sometimes seen in new arrivals to an area. They may suffer from mild digestive disturbances, diarrhœa or frequent colds, until they become what is known as acclimatised, i.e. accustomed to the place. The process of acclimatisation is probably the natural acquirement of an active immunity to the common bacteria of the region.

CHAPTER II

THE ANATOMY AND ELEMENTARY PHYSIOLOGY OF THE HUMAN BODY

THE sanitary officer should know something of the structure of the following systems of the human body the alimentary circulatory respiratory and excretory systems.

The Alimentary System may be regarded as a long muscular tube extending inside the body from the mouth to the anus. Its function is to change the food into constituents which can be easily absorbed by the blood and to reject those substances which are of no use to the body For this purpose the alimentary canal is furnished with, in the mouth, the teeth, which in the action of chewing break up the food into small pieces which can be con veniently swallowed. The tongue and the cheeks assist in this movement. Opening into the mouth are the openings of the salivary glands, the principal pair of which are known as the *parotid glands* which lie in either cheek just in front of the ears. These glands produce a fluid known as *saliva* which is discharged into the mouth on each side by a small opening inside the cheek lying at the level of the second upper molar tooth. The saliva moistens the food and lubricates it so that it is easily swallowed. It also contains a ferment known as *ptyalin* which begins to digest the starch in the food and to convert it into a more easily absorbed substance known as *glycogen*. The saliva does not act upon meats, cheese or fatty substances but only on starch. In the neck and the chest the alimentary canal has a thick muscular wall and in this region of the body it is known as the *œsophagus* The œsophagus pierces the umbrella-shaped muscle (the *diaphragm*) separating the chest from the abdomen and immediately expands into a bag known as the *stomach*. Here the food is retained for a number of hours. The stomach is lined with large numbers of small glands which, when food is introduced into it, pour out the secretion known as the gastric juice. This juice

contains *hydrochloric acid* and a number of *ferments*, each of which has its particular action on the different constituents of the food not acted upon by the saliva, the final result being that the solid food is converted into a liquid containing many substances having little resemblance to the food originally taken. While digestion is going on the muscular wall of the stomach is contracting and expanding rhythmically so that the food is well churned up in the gastric juice. As the food becomes digested it passes out of the stomach into the part of the alimentary canal which is now cylindrical and is known as the small intestine.

The small intestine is about 7 metres long Moreover it has an enormous surface area because its lining membrane is thrown into multitudinous folds. In addition to this the whole surface is covered with extremely small finger-like projections known as *villi* (singular *villus*) In the upper part of the small intestine known as the *duodenum* there are the openings of the ducts of two large digestive glands—the *liver* and the *pancreas*. These pour their secretion into the duodenum where it mixes with the secretion covering the villi and with the food which has been forced out of the stomach These juices create further changes in the food which make it absorbable by the lymph circulating through loops of tiny lymph vessels in the villi

The rhythmical contraction and relaxation of the muscular wall of the small intestine brings the food intimately into contact with the absorbing structures known as the villi and at the same time keeps it moving gradually down the canal. The soluble parts of the food are absorbed by the lymph circulating in the hair-like tubes inside the villi and eventually reach the blood.

The upper two-fifths of the small intestine following the duodenum is known as the *jejunum* the lower three fifths the *ileum*.

At the end of the ileum the canal enters the expanded portion known as the *large intestine* or *colon*. This part of the alimentary canal is about 1.5 metres long The ileum joins it almost at right angles and below the junction the colon has a blind end known as the *cæcum*.

Near where the ileum joins the colon there is a small worm like expansion about 9 cm. in average length known as the *vermiform* (or worm-like) *appendix*. When this structure becomes inflamed the patient suffers from appendicitis.

The colon has a much wider diameter than the small intestine

small flattened biscuit-shaped bodies known as the *erythrocytes* or *red blood corpuscles* and far less numerous spherical glistening bodies known as *leucocytes* or *white blood corpuscles* (Fig 1 7) If the preparation is left for some time microscopic threads of a substance known as *fibrin* will be seen extending between and over the corpuscles, preventing their movement, and forming a kind of membrane known as a *clot*. Clotting of the blood only takes place when the blood is removed from the blood vessels. So long as the body is healthy the blood never clots inside the vessels unless these are injured or blocked, and even then the clotting is limited to the injured part. If blood is drawn and allowed to clot in a dish, the clot shrinks after a time and a clear fluid is pressed out of it. This fluid is known as *serum*.

The tube in which the blood is confined is an endless tube in the bore of which there is a valvular pump known as the heart.

The heart is a hollow muscular bag which may be regarded as an expansion of the circulatory canal much in the same way as the stomach was regarded as an expansion of the alimentary canal. But the heart has different work to perform than has the stomach, so its structure is different. It does two things it forces the blood through the lungs, and after the blood has circulated through the lungs it forces it through the other parts of the body What makes the subject difficult for the beginner to understand is that these two movements take place simultaneously so that the contraction of the heart which forces part of the blood through the lungs forces another part through the body

In order to get rid of its gaseous impurities and to take up the oxygen of the air the blood coming from the body which is under a low pressure must pass through the lung by way of the heart. The heart is separated by a vertical muscular partition into two sides and each of these sides is further separated by a horizontal valve into two further chambers. The two upper chambers of the heart are known as *auricles* they are chambers of low pressure and their walls are therefore thin. The two lower chambers are the pump of the heart. They have to raise the pressure of the blood in them to a much higher degree than is ever effected in the auricles so that their muscular walls are very thick, when compared with those of the auricles, and they are known as the *ventricles* The human heart may therefore be represented as shown in Fig 3

The mechanism of the human heart is as follows. While the

ventricles are resting blood is coming into both auricles on the right side impure blood from the body into the right auricle, and on the left side purified blood from the lungs into the left auricle. This blood is all under low pressure and the vessels which convey it towards the heart are known as *veins* When the auricles are full their muscular walls begin to contract simultaneously and the wave of contraction passes over them in such a way that the blood is forced into the ventricles. Since the wave begins at the part of the auricles where the veins enter the openings of the veins are shut and the blood is prevented from

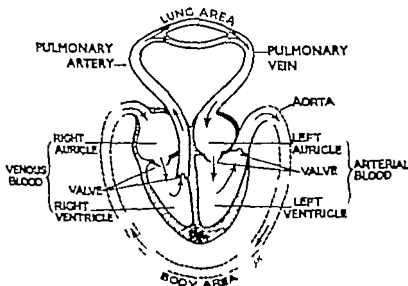


FIG. 3 —Diagrammatic representation of human heart.

backing into them. The wave then spreads downwards from the auricles to the flabby muscular walls of the ventricles which then powerfully contract, and greatly reduce the capacity of the cavity contained by them. As the blood pressure rises with the con traction of the ventricles the flaps of the valves between the auricles and the ventricles are forced together with a clap (which can be heard on listening with the ear in contact with the chest over the region of the heart) and the blood is thus prevented from being forced back into the auricles. The pressure in the ventricle continues to rise with the progress of the ventricular contraction until the valves guarding the arteries are forced open

and the blood is propelled along them under pressure the impure blood from the right ventricle being driven to the lungs through *the pulmonary artery* the purified blood from the left ventricle being forced through the main artery of the body known as the *aorta*. When the ventricles are emptied they relax. The pressure of the blood in the arteries closes the arterial valves with an audible click and prevents the blood from spurting back into the ventricles. The elastic recoil of the arterial walls drives the blood onwards, on the right side, through the pulmonary artery to the lungs and on the left side through the aorta to the rest of the body

After a brief period of rest during which the relaxed auricles are filling with blood the contraction wave begins again in the auricles and the circulation is thus effected by the alternate con traction and relaxation of the heart.

Let us now trace the course of the blood tube through the tissues and back to the heart. As the aorta emerges from the heart it is a stout tube about as thick as one s thumb The wall of the tube is thick and elastic because it is composed of muscular and elastic elements. If we could see it we would see that it is always full, but that with each contraction of the ventricles it suddenly stretches, and a wave of pressure is rapidly conveyed along its walls, which can be felt as the *pulse* when arteries lie near the surface. As the aorta passes through the chest and down into the abdomen it branches just like the roots of a tree, each branch growing smaller by further branching until it becomes too small to be seen by the naked eye. The smallest part of the arterial system is a very fine tube composed almost entirely of muscular tissue whose expansion and contraction can alter the capacity of the tube as circumstances dictate. It is at this point that the pulse wave of the heart is no longer perceptible. The smallest branches of the arteries subdivide into even smaller vessels known as *capillaries* which cannot be seen by the naked eye, through which the blood flows in a steady stream. The blood capillaries mingle with the lymph capillaries but do not join up with them. The lymph of the blood can ooze through the thin walls of these capillaries to mingle with the lymph bathing the body cells and in this way prevent the stagnation of the lymph in the body The blood cells are thus brought into contact with the body lymph, though they do not leave the capillaries but are borne quickly through them. During this part

of their journey the red blood corpuscles give off the oxygen absorbed *in the lungs and take up by means of their hæmoglobin* the carbon dioxide given off as a waste product of tissue activity The blood in this process loses its bright red colour and becomes darker As the blood discharges its food materials and takes up waste matters it flows into capillary vessels which now begin to unite together to form small veins. These small veins unite to form larger veins until, in the reverse direction, we have a venous system resembling the arterial system which ends eventually in the right side of the heart, after picking up the lymph on the way This circulation is known as the systemic system, and its object is largely to provide for the nourishment of the body although, as will be seen, a certain amount of purification of the blood takes place in it.

The system of the circulation of the blood through the lungs is known as the pulmonary system. By this system the blood is *conducted from the right ventricle through the pulmonary artery* to the lungs. At the lungs the artery branches, some of the blood travelling to the right lung, the rest to the left. In the lungs a similar branching of the arteries takes place, ending in a capillary system in contact with the tiny air cells of the lung (Fig 8). While the blood is circulating through these capillaries it gives off the carbon dioxide obtained in its circulation through the body tissues and takes up oxygen, which is stored in the hæmoglobin of the red blood corpuscles. The carbon dioxide is breathed out and the oxygen is carried by the blood, which has now regained its bright red colour through the pulmonary veins to the left auricle from which it is forced by the contraction of the heart through the left ventricle and aorta into the systemic circulation again.

In the systemic circulation there is a very important subsidiary system known as the *portal system* which is concerned with the absorption from the alimentary canal of foodstuffs other than fat and with an important organ, the *spleen*, which acts as a kind of factory for the storage, destruction, repair and replacement of the cells of the blood.

The stomach, small intestine and spleen have blood brought to them by arteries which are branches of the systemic circulation. In the spleen these branches divide up into a network of capillary vessels which come into intimate contact with the cells composing

the spleen substance. These cells are of different kinds. Some remove from the blood worn-out red blood corpuscles and replace them with new ones. Others remove and replace worn-out white corpuscles. They may also remove insoluble matters from the blood so that we may look upon the spleen as a sort of maintenance factory of the blood.

After a patient has suffered from malaria for some time the quantity of insoluble matter and damaged blood cells stored in the spleen may be so great as to distend the organ to such an extent as to make it easily felt in the patient's abdomen. The

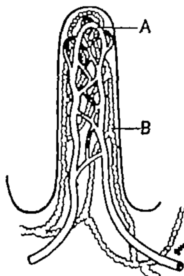


FIG. 4.—Diagram of an intestinal villus.
A. Blood capillary B. Lymph capillary.

healthy spleen is tucked up under the ribs on the left side of the body and cannot usually be felt through the abdominal wall.

We have already learnt the structure of a villus in the intestine, and have seen that it is a very tiny finger-like structure containing a small artery which breaks up into capillaries which reunite into a small vein. We have also seen that in addition to this loop of artery and vein there is a loop of tiny lymphatic vessels (Fig. 4). As the food is prepared for absorption in the intestine the fatty parts of it are absorbed by the lymphatics of the villi while those constituents derived from the proteins and carbohydrates are absorbed by the systemic capillaries and are carried by the portal system of veins to the liver where they are stored, to be

released in the intervals between meals according to the needs of the body After the liver has removed from the portal blood the excess foodstuffs it contains it passes the blood into one of the big veins which opens into the right auricle of the heart. The three systems may be diagrammatically represented thus.

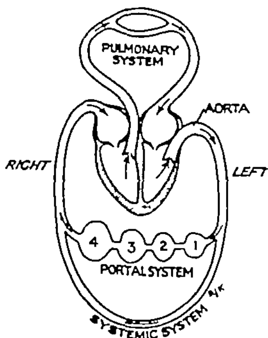


FIG. 5.—Diagrammatic representation of th various circulatory systems.
1. Spleen. 2. Stomach. 3. Intestines. 4. Liver

The Lymphatic System

As the blood flows through the capillary blood vessels part of its nutrient lymph oozes out through the extremely thin walls of these vessels and dislodges the lymph bathing the tissues. The lymph so dislodged, which is laden with the waste products of cellular activity finds its way into a separate set of capillary vessels known as the lymph capillaries which are much the same size as the capillary blood vessels. The lymph capillaries join together to form larger lymph vessels in the same way as the blood capillaries join to form tiny veins. Sooner or later numbers of these lymph vessels, or *lymphatics* as they are called,

converge on an organ known as a *lymphatic gland*. The lymphatic gland is rather like a very small sponge, the spaces of which are filled with cells whose function it is to remove from the lymph such things as bacteria and certain waste products resulting from the wear and tear of tissue cells or from their destruction.

The lymph entering the lymphatic gland flows among the gland cells and any impurities such as those just mentioned are removed from it. The purified lymph leaves the gland by a lymphatic which may communicate with another gland, or collection of glands, but eventually reaches that part of the body in front of the vertebral column when it pours its lymph into a connecting channel known as the *thoracic duct* The thoracic duct runs forwards and ends by joining up with one of the large veins of the neck. It receives the lymph from the greater part of the body The lymph from the rest of the body is collected in a similar vessel, but much shorter which also enters a large vein.

There is nothing in the lymphatic system corresponding to the heart. The lymph is driven through the lymphatic system by a number of forces. The pressure of the lymph oozing out of the blood capillaries displaces the lymph bathing the tissue cells and drives it into the lymph capillaries. When once it is in the capillary lymphatic vessels the contraction of the muscles drives it along into the lymphatics and towards the thoracic duct. The act of breathing, by rhythmically increasing and diminishing the capacity of the chest and abdomen, acts upon the thoracic duct like a pump which, in combination with innumerable one-way valves made the lymphatics, compels the lymph to travel in a constant direction which is, *in health, always towards the heart.*

Lymph vessels are absent from the central nervous system, the voluntary muscles and such non vascular structures as cartilage and nails.

The Respiratory System

Before a baby is born its lungs are solid structures. After the child emerges from the birth passage air rushes through the baby's nostrils and mouth and inflates the lungs just as one might inflate a child s toy balloon by blowing air into it. On this happening the child cries and the act of breathing is begun, which never stops until he dies.

The lungs are the organs which aerate the blood, and to under stand how this is done it is necessary to know how they are constructed. Let us first of all consider the chest.

The chest is the upper cavity of the body which is more or less like a pyramid with the top cut off the narrow upper part communicating with the neck and the lower part being sealed by a large umbrella shaped muscle known as the *diaphragm* This cavity is divided into two sides by a space known as the *mediastinum* which contains the heart, the great blood vessels, the œsophagus, important nerves and the trachea and bronchi as well as the supporting structures and the small blood and lymphatic vessels and the nerves which nourish and regulate them.

The chest is enclosed by a number of rigid curved bones known as the *ribs* which lie more or less parallel to one another but run obliquely downwards from back to front. They are hinged to the backbone behind and to a flat bone in front known as the *sternum* or *breast bone* and to a cartilaginous expansion of it on both sides. The spaces between the ribs are occupied by thin bands of muscle.

The lower part of the chest is closed by the large dome shaped diaphragm. This muscle is attached to the lower ribs and to the structures covering the backbone behind and to the lower part of the sternum and the lower ribs in front. It com pletely separates the chest from the abdomen, and it is pierced by the œsophagus and the large arteries, veins and nerves which serve the lower parts of the body When the diaphragm is re laxed it is dome-shaped when it contracts the upper part is pulled down and it becomes flatter

We have seen that the cavity of the chest is divided into two compartments by the mediastinum. Each of these compartments is lined by a membrane known as the *pleura*. The lung grows into the compartment from the mediastinum and in its growth it pushes the part of the pleura in contact with it into the compartment so that when the lung is fully grown the pleura covers it entirely and the two layers of pleura which used to be separ ated, the one part lining the cavity and the other part covering the lung come into contact with each other and are lubricated by a secretion which allows the movable pleura over the elastic lung to move freely against that part of the pleura lining the chest wall and fixed to it (Fig 6).

In the unborn infant the lung appears to be a solid organ. It

converge on an organ known as a *lymphatic gland* The lymphatic gland is rather like a very small sponge, the spaces of which are filled with cells whose function it is to remove from the lymph such things as bacteria and certain waste products resulting from the wear and tear of tissue cells or from their destruction.

The lymph entering the lymphatic gland flows among the gland cells and any impurities such as those just mentioned are removed from it. The purified lymph leaves the gland by a lymphatic which may communicate with another gland, or collection of glands, but eventually reaches that part of the body in front of the vertebral column when it pours its lymph into a connecting channel known as the *thoracic duct*. The thoracic duct runs forwards and ends by joining up with one of the large veins of the neck. It receives the lymph from the greater part of the body The lymph from the rest of the body is collected in a similar vessel, but much shorter which also enters a large vein.

There is nothing in the lymphatic system corresponding to the heart. The lymph is driven through the lymphatic system by a number of forces. The pressure of the lymph oozing out of the blood capillaries displaces the lymph bathing the tissue cells and drives it into the lymph capillaries. When once it is in the capillary lymphatic vessels the contraction of the muscles drives it along into the lymphatics and towards the thoracic duct. The act of breathing by rhythmically increasing and diminishing the capacity of the chest and abdomen, acts upon the thoracic duct like a pump which, in combination with innumerable one-way valves inside the lymphatics, compels the lymph to travel in a constant direction which is, in health, always towards the heart.

Lymph vessels are absent from the central nervous system, the voluntary muscles and such non vascular structures as cartilage and nails.

The Respiratory System

Before a baby is born its lungs are solid structures. After the child emerges from the birth passage air rushes through the baby's nostrils and mouth and inflates the lungs just as one might inflate a child's toy balloon by blowing air into it. On this happening the child cries and the act of breathing is begun, which never stops until he dies.

walls its carbon dioxide and take up the oxygen from the air in the lung

The act of breathing aerates the interior of the lungs by rhythmically stretching and relaxing their elastic walls. In the act of inspiration the diaphragm flattens and the spaces between the ribs are increased by raising their lower ends by muscular action. This increases the chest-cavity in which the pressure is low so that air rushes into the lungs to fill up the space and so

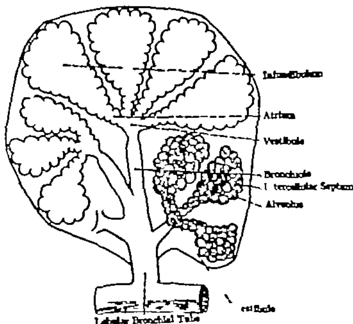


Fig. 7—Diagrammatic representation of a lobule of the lung

(From Buchanan's Manual of Anatomy.)

stretches them. The opposite movement is expiration, the diaphragm relaxes and rises into the chest, the front parts of the ribs sink by the relaxation of the muscles attached to them, the chest-cavity accordingly becomes smaller and the impure air is expelled.

If we trace the respiratory system from the nose and mouth we find that it leads into a tube known as the *trachea*. This tube is kept open by having in its walls a series of cartilaginous rings. It is about 11 cm. long and runs downwards in the neck in the middle line just in front of the œsophagus. At its lower part it

is not entirely solid because it is so constructed as to be riddled with little spaces which communicate with the open air through the tubes, known as the bronchi and trachea, which open into the nose and mouth. Surrounding these spaces, which in the unborn child are *obliterated*, there is a network of capillary blood vessels in elastic tissue. The small solid lungs project into the compartments of the chest on either side where the pressure exerted on them is much less than that exerted by the

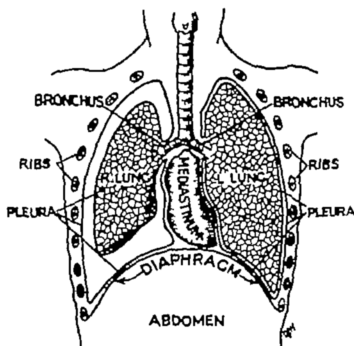


FIG 6.—Diagram of lungs and pleura.
The right lung is shown partially inflated and carrying the mediastinal pleura out into the pleural cavity

air on the outside, which is at a pressure of about 15 lb. to the square inch. When the mouth of the child reaches the open air in the act of birth the air rushes in through the nose and mouth, down the open trachea, into the bronchi and blows out the little air spaces until the lung is stretched to such an extent as to make it fill the corresponding compartment of the chest. The stretching of the lung tissues makes them very thin so that the blood circulating in the lung capillaries can give off through the capillary

sponge-like. The blood circulates through them in capillary blood vessels in the walls of the kidney spaces and as it does this the kidney cells take from the blood and concentrate certain of its impurities. These are dissolved in water which runs in minute channels to the inner margin of the kidney where the channels unite and expand into a fibrous bag known as the *pelvis* of the kidney From the pelvis of the kidney this concentrated solution of waste salts from the blood now known as urine, passes down a long narrow tube known as the *ureter* to the *bladder* a hollow muscular organ lying in the lower part of the abdomen known as the *pelvis* (The word pelvis is a latin word meaning basin." It is used in anatomical description under the term *the* pelvis to denote the basin-like formation of bones at the lower part of the backbone and abdomen. It is also used to describe the membranous collecting part of a gland or organ into which the excretory or secretory tubules open, in which case it is seldom referred to as *the* pelvis but usually as the pelvis of the organ or gland concerned, e.g the pelvis of the kidney)

The bladder is the collecting and excretory organ of the urine. It has a thick muscular wall when empty which is pierced by the two ureters. As it fills with urine the wall stretches. The wall contains arteries, veins and lymphatics, and is lined by a mucous membrane. At the lower part of the bladder a tube known as the *urethra* conducts the urine to the exterior The act of voiding the urine is known as *micturition* (verb *to micturate*)

The Skin

The skin covers the body and protects the structures lying underneath. It contains delicate organs of sensation it plays an important part in the regulation of the temperature of the body and it acts as one of the less important excretory organs.

The skin may be regarded as composed of two layers of tissue The outer layer is known as the epidermis and the inner layer of vascular connective tissue is known as the true skin. The outer layer consists of a series of cells which vary in shape from the layers of cubical growing cells lying directly on the very vascular true skin and deriving their nourishment from it, to flattened, dead and horny remnants which constitute the more superficial layer The epidermis is pierced by the ducts of the sweat glands which lie embedded in the true skin (Fig 9).

divides into two branches, the right and left *bronchi* which resemble the trachea in that they have cartilaginous rings in their walls to keep them open. The bronchi branch pretty much in the same way as the arteries branch until they end in small muscular tubes known as *bronchioles* The bronchioles end in collections of little sacs known as *infundibula* which are studded with small projections known as *alveoli* which make them look like little raspberries (Fig 7) It is on the walls of the alveoli that

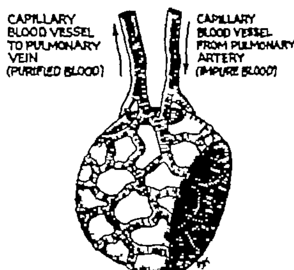


FIG. 8—Diagram of an alveolus.

Part of the little sac has been cut away to show the interior which is filled with air

the capillary blood vessels of the pulmonary system run and through which the blood is aerated (Fig 8)

The Renal System

Many of the solid waste products of the body are voided in the fæces which come from the alimentary canal. The gaseous waste product, carbon dioxide, leaves the body through the lungs in the expired air But there are other waste products which are soluble in the blood and are removed from it by the action of two organs situated one on each side of the abdomen, known as the kidneys.

Though the kidneys appear to be solid organs they are really

One way in which the heat of the body is regulated is by increasing the loss of heat through the skin. When this occurs the sweat glands make the skin damp by pouring out the sweat on to its surface, and the dilatation of the capillary blood vessels in the papillæ makes room for a large increase in the amount of overheated blood circulating just beneath the surface and exposed to the great cooling effect of the evaporating sweat.

The true skin is tough, flexible, and elastic. It varies in thickness in different parts of the body On its outer surface it bears innumerable tiny projections known as the papillæ in

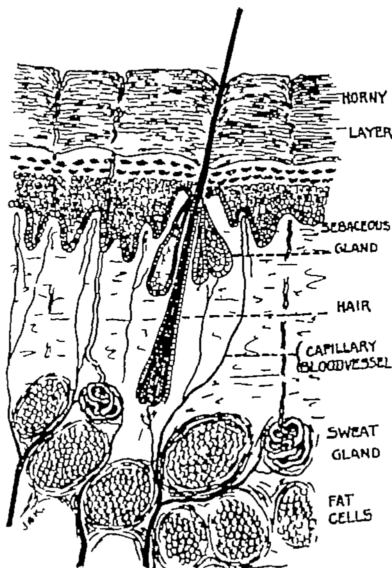


FIG 9—Section of the skin.
(Modified from MacKenna' Diseases of the Skin.)

which there is a loop of capillary blood vessels and other structures. Embedded in the true skin are the sweat glands, the roots of the hairs and the nails.

The Collection of Vital Statistics.—The collection and study of the vital statistics of the people is a most important means of discovering conditions affecting their health. Since the statistics are comparative it is first necessary to know the number of persons in the area. This is done by means of a census, or counting of the people. In the census returns information is required of the sex and age of the inhabitants, their civil state occupation or trade, and other matters of interest. Since the making of a census is a costly undertaking governments generally make it at ten-year intervals. For the study of population figures and other statistics in the intervening years the population is estimated by various means. Vital statistics are compared with the population as it is estimated to be at the 30th June since what is wanted is the average population for the year under review

Death-rate.—The death-rate is the number of persons dying in a year per thousand of the average population of that year This is known as the crude death-rate. To find out the death rate of the local population there must be deducted from the total number of deaths the number of deaths of persons dying in the area but not resident in it (patients coming from outside the area dying in hospitals, deaths of visitors) and there must be added to it the deaths of residents occurring elsewhere while they have been temporarily absent. The death rate calculated after these and other corrections have been made is known as the corrected or standard death-rate.

Birth-rate.—The birth rate is the number of births registered in a year per thousand of the population for that year This gives some indication of the fertility of the population.

The Infantile Mortality Rate is the number of deaths of infants under one year of age per thousand registered births of the year This rate gives a valuable indication of the wastage of infant life and directs enquiry into the whole subject of infant and child welfare.

Infectious Diseases Death rate is the number of persons dying from infectious diseases per thousand of the population.

The Case Mortality Rate is the number of persons dying from a disease in every hundred persons suffering from it. This rate is a measure of the fatality of the disease.

Isolation of the Patient.—Isolation of the patient means placing the patient under such conditions as will prevent the disease from which he suffers from spreading to other persons. There

CHAPTER III

COMMUNICABLE DISEASES

General Means of Dealing with Such Diseases

It is important to realise that the Sanitary Authority cannot do what it likes It must obtain its powers from the Government in the form of laws which usually specify the limits to which the Sanitary Authority can go in applying the measures necessary for its work. While these laws are concerned mainly with the grant of power to the Sanitary Authority they also lay upon the people the duty of supporting all legal measures instituted by the Sanitary Authority and they prescribe penalties for the correction of those members of the public who fail to co-operate. It is, however undesirable for the officers of the Sanitary Authority to have recourse to the law until discussion with those concerned has failed to obtain their co-operation.

The control of communicable diseases by the Sanitary Authority involves one or two procedures to which reference may be made in a general way before the individual diseases are discussed.

In the first place control is almost impossible without an *infectious diseases notification act* This is an enactment which makes it compulsory for persons who become aware of the occurrence of any of the communicable diseases specially mentioned in the Act to notify the Sanitary Authority of the area at once, stating as a minimum the name, sex and age of the patient, his address, and the disease from which he is suffering In actual practice notification is made by the doctor in attendance on the patient. A fee payable by the Sanitary Authority is generally paid to the person making the notification.

The need for such an act is clear One cannot hope to control communicable disease unless one has early information regarding its occurrence. Delay means danger to others through the increased opportunity provided for the spread of the disease.

The Collection of Vital Statistics—The collection and study of the vital statistics of the people is a most important means of discovering conditions affecting their health. Since the statistics are comparative it is first necessary to know the number of persons in the area. This is done by means of a census, or counting of the people. In the census returns information is required of the sex and age of the inhabitants, their civil state, occupation or trade, and other matters of interest. Since the making of a census is a costly undertaking governments generally make it at ten-year intervals. For the study of population figures and other statistics in the intervening years the population is estimated by various means. Vital statistics are compared with the population as it is estimated to be at the 30th June since what is wanted is the average population for the year under review

Death-rate—The death rate is the number of persons dying in a year per thousand of the average population of that year This is known as the crude death rate. To find out the death-rate of the local population there must be deducted from the total number of deaths the number of deaths of persons dying in the area but not resident in it (patients coming from outside the area dying in hospitals, deaths of visitors) and there must be added to it the deaths of residents occurring elsewhere while they have been temporarily absent. The death-rate calculated after these and other corrections have been made is known as the corrected or standard death rate.

Birth-rate—The birth-rate is the number of births registered in a year per thousand of the population for that year This gives some indication of the fertility of the population.

The Infantile Mortality Rate is the number of deaths of infants under one year of age per thousand registered births of the year This rate gives a valuable indication of the wastage of infant life and directs enquiry into the whole subject of infant and child welfare.

Infectious Diseases Death-rate is the number of persons dying from infectious diseases per thousand of the population.

The Case Mortality Rate is the number of persons dying from a disease in every hundred persons suffering from it. This rate is a measure of the fatality of the disease.

Isolation of the Patient—Isolation of the patient means placing the patient under such conditions as will prevent the disease from which he suffers from spreading to other persons. There

is therefore more in isolation of the patient than merely keeping him and his attendant apart from others. Effective isolation of patients requires accurate knowledge of the means of spread of disease. Let us consider two examples. Isolation of a case of yellow fever means keeping the patient under conditions which will prevent the access to him of the mosquito which is the transmitter of the infection to other human beings. Nothing more need be done. In the absence of the yellow fever mosquito a yellow fever patient is harmless to the community if we except those in immediate attendance upon him, who are only in danger if they are doing work which may bring them into contact with his blood, e.g laboratory workers taking or working with blood samples. Nursing the patient under a mosquito-net, or better in a mosquito-proof room, is therefore all that need be done to isolate effectively a patient suffering from yellow fever At the other end of the series we have the patient suffering from typhoid fever in which disease the typhoid bacilli which are the cause of the illness are excreted in the stools and urine of the patient. They can live for a certain length of time outside the human body and the infection can be spread, not only by those in attendance on the patient but also by flies, ants or cockroaches which may get access to soiled dressings, soiled bedclothing, the stools or urine of the patient, and contaminate themselves by feeding on the contaminated material or even by contact with it. Since these insects feed indiscriminately upon human dejecta and human food they may easily contaminate human food with typhoid bacilli which have lost none of their vigour during their short sojourn with the insect, and are consequently able to cause the disease in persons living at some considerable distance from the patient who consume the polluted food. The ability of the typhoid bacillus to live for some time outside the human body makes the pollution of water supplies with infected material another means of spread of the disease, in which case the disease may be water-borne, or spread by milk contaminated by dairy utensils washed in the contaminated water The practice in some countries of using human excreta as fertiliser for market gardens renders green vegetables usually consumed raw another means whereby the disease may be spread. The isolation of a patient suffering from typhoid fever therefore, is very different from the isolation of the case of yellow fever It means a careful and scrupulous disinfection *in the patient's room* of all articles, dressings, bed-

clothing and handkerchiefs used by the patient, as well as the disinfection of his fæces and urine and the vessels into which they are passed. And this should be continued throughout the period of his convalescence No article or substance should leave the patient's room until it has been thoroughly disinfected. Those in attendance on the patient should wear an overall which can be disinfected without damage they should consume no food in the patient's room, and before leaving the room they should carefully disinfect their hands. From this it will be seen that the best place for the effective isolation of a patient suffering from typhoid fever is an infectious diseases hospital where all the small but extremely important details of disinfection are carried out by a trained staff as a matter of routine.

Spot Maps.—Spot maps are very useful in the control of an outbreak of communicable disease. They are maps of the area on which are marked by a spot or other character the places where cases of the disease have occurred. A spot map gives the Sanitary Authority a record of the way in which the disease is spreading through the area and from it one may be able to learn how the disease is being spread, e.g. by contacts, by water by flies or by milk. The information conveyed by the map must, of course, be supplemented by local knowledge of the habits of the people, and when it is so supplemented it may at least given an indication of the most profitable line of enquiry to pursue in one's endeavour to trace the source of the infection. If for instance, a number of cases of typhoid fever are seen to occur in villages bordering a certain stream, the water of which is known to be used by the villagers the indication would be to search for a person who had suffered recently from the disease somewhere up-stream from the infected villages. If he were still alive he might be a carrier continually polluting the stream by his unhygienic habits. Action taken to prevent him from polluting the stream would probably see the last of the typhoid fever farther down. Or it may happen that the distribution of the cases fol lowed the route of a milkman in a town. Here the probability is that the outbreak was caused by polluted milk supplied by this milkman.

It is seldom that one gets such clear indications in the tropics, except in the larger cities. But it is always worth while to plot all cases of communicable disease on a map of the area in which they are occurring on the chance that a clue may be given

to the origin or method of spread of the disease causing the *outbreak.*

Surveillance and Observation of Contacts

The word contact when used in connection with the control of communicable disease means a person who by his association with the patient or with articles used by the patient during the period of presumptive infectiousness has made himself liable to contract the infection. Note that the contact by this definition need never have seen the patient at all. He may only have been handling the patient's clothing and bedding (smallpox, etc.), or he may have been living on the same premises though not necessarily in the same house as the patient (plague, etc.). In actual practice only contacts in relatively close connection with the patient or his premises can be dealt with.

When contacts are placed under surveillance they are allowed their freedom but are required to submit to periodical *medical examination during the period of the surveillance.* The object of this is to detect new cases of the disease at the earliest possible moment, and to isolate the new patients before they become a danger to others. If the contacts cannot be trusted to comply with the conditions under which they are placed under surveillance they may if the law so provides, be placed under observation. This means that they are obliged to submit to being confined on premises provided by the Sanitary Authority for the purpose, for the specified length of time required by the disease with which they may have been in contact. During their confinement they are not allowed visitors and they must submit to whatever medical procedure is necessary for the diagnosis of the disease with which they are presumably infected. The term quarantine means pretty much the same thing The essential difference between surveillance and observation is the strict isolation of the contacts and the temporary deprivation of their liberty which is involved by observation or quarantine.

Control of Movement

One useful measure for limiting the spread of communicable *disease prone to epidemic occurrence* is the control of movement of the people in the threatened areas. This is usually done in co-operation with the police.

It is seldom practicable to enforce a universal standstill order in an extensive area. Nor is it necessary Control of movement is more acceptable to the people and is likely to be just as effective as the more rigorous standstill order Under control travel may be made conditional upon the immunisation of intending travellers against the disease concerned e.g inoculation against cholera, vaccination against smallpox, inoculation against yellow fever or typhus fever upon a disinfection of their clothing and baggage (typhus fever plague, smallpox) or medical examination prior to the journey Arrangements have to be made to enable intending travellers to have these measures carried out and a system of travel permits instituted by the Health Authority in collaboration with the police. Such permits are issued only to applicants who satisfy the requirements of the Sanitary Authority

Carriers

One would think that the presence of a pathogenic organism in any part of the body would result either in the destruction of the organism or the injury of the tissues on which the organism was growing. But it often happens that a pathogenic organism can establish itself in the body of a perfectly healthy person and remain established there, often for long periods, without causing any impairment of the health of the person so infected Such a person is known as a carrier and he may be very dangerous because, though he suffers no ill effects from his infection, and indeed may be quite ignorant of the fact that he is infected at all, he may spread the organism by his unhygienic habits and be the unsuspected cause of an outbreak of disease.

Since the carrier is apparently in perfect health his connection with outbreaks of disease originating from him can only be made by inference. For instance, a certain cook may occupy a number of posts, and in each household in which she works sporadic cases of typhoid fever occur It may not be until some considerable time has elapsed that suspicion may be directed against her and so she may do a great deal of harm before she is discovered. Definite proof of the carrier state can only be obtained by special methods of examination directed to the discovery in the carrier or in his excretions, of the organism concerned.

It is now the practice where means exist for carrying out the necessary procedure, to search for carriers in connection with certain of the communicable diseases. The diseases in which the

to the origin or method of spread of the disease causing the outbreak.

Surveillance and Observation of Contacts

The word contact when used in connection with the control of communicable disease means a person who by his association with the patient or with articles used by the patient during the period of presumptive infectiousness has made himself liable to contract the infection. Note that the contact by this definition need never have seen the patient at all. He may only have been handling the patient's clothing and bedding (smallpox, etc.), or he may have been living on the same premises though not necessarily in the same house as the patient (plague, etc.). In actual practice only contacts in relatively close connection with the patient or his premises can be dealt with.

When contacts are placed under surveillance they are allowed their freedom but are required to submit to periodical medical examination during the period of the surveillance. The object of this is to detect new cases of the disease at the earliest possible moment, and to isolate the new patients before they become a danger to others. If the contacts cannot be trusted to comply with the conditions under which they are placed under surveillance they may if the law so provides, be placed under observation. This means that they are obliged to submit to being confined on premises provided by the Sanitary Authority for the purpose, for the specified length of time required by the disease with which they may have been in contact. During their confinement they are not allowed visitors and they must submit to whatever medical procedure is necessary for the diagnosis of the disease with which they are presumably infected. The term quarantine means pretty much the same thing The essential difference between surveillance and observation is the strict isolation of the contacts and the temporary deprivation of their liberty which is involved by observation or quarantine.

Control of Movement

One useful measure for limiting the spread of communicable disease prone to epidemic occurrence is the control of movement of the people in the threatened areas. This is usually done in co-operation with the police.

It is seldom practicable to enforce a universal standstill order in an extensive area. Nor is it necessary Control of movement is more acceptable to the people and is likely to be just as effective as the more rigorous standstill order Under control travel may be made conditional upon the immunisation of intending travellers against the disease concerned, e.g inoculation against cholera, vaccination against smallpox, inoculation against yellow fever or typhus fever upon a disinfection of their clothing and baggage (typhus fever plague, smallpox) or medical examination prior to the journey Arrangements have to be made to enable intending travellers to have these measures carried out and a system of travel permits instituted by the Health Authority in collaboration with the police. Such permits are issued only to applicants who satisfy the requirements of the Sanitary Authority

Carriers

One would think that the presence of a pathogenic organism in any part of the body would result either in the destruction of the organism or the injury of the tissues on which the organism was growing But it often happens that a pathogenic organism can establish itself in the body of a perfectly healthy person and remain established there, often for long periods, without causing *any impairment of the health of the person so infected.* Such a person is known as a carrier and he may be very dangerous because though he suffers no ill effects from his infection, and indeed may be quite ignorant of the fact that he is infected at all, he may spread the organism by his unhygienic habits and be the unsuspected cause of an outbreak of disease.

Since the carrier is apparently in perfect health his connection with outbreaks of disease originating from him can only be made by inference. For instance, a certain cook may occupy a number of posts, and in each household in which she works sporadic cases of typhoid fever occur It may not be until some considerable time has elapsed that suspicion may be directed against her and so she may do a great deal of harm before she is discovered. *Definite proof of the carrier state can only be obtained by special methods of examination directed to the discovery* in the carrier or in his excretions, of the organism concerned.

It is now the practice where means exist for carrying out the necessary procedure to search for carriers in connection with certain of the communicable diseases The diseases in which the

to the origin or method of spread of the disease causing the outbreak.

Surveillance and Observation of Contacts

The word contact when used in connection with the control of communicable disease means a person who by his association with the patient or with articles used by the patient during the period of presumptive infectiousness has made himself liable to contract the infection. Note that the contact by this definition need never have seen the patient at all. He may only have been handling the patient's clothing and bedding (smallpox, etc.) or he may have been living on the same premises though not necessarily in the same house as the patient (plague, etc.). In actual practice only contacts in relatively close connection with the patient or his premises can be dealt with.

When contacts are placed under surveillance they are allowed their freedom but are required to submit to periodical medical examination during the period of the surveillance. The object of this is to detect new cases of the disease at the earliest possible moment, and to isolate the new patients before they become a danger to others. If the contacts cannot be trusted to comply with the conditions under which they are placed under surveillance they may if the law so provides, be placed under observation. This means that they are obliged to submit to being confined on premises provided by the Sanitary Authority for the purpose, for the specified length of time required by the disease with which they may have been in contact. During their confinement they are not allowed visitors and they must submit to whatever medical procedure is necessary for the diagnosis of the disease with which they are presumably infected. The term quarantine means pretty much the same thing The essential difference between surveillance and observation is the strict isolation of the contacts and the temporary deprivation of their liberty which is involved by observation or quarantine.

Control of Movement

One useful measure for limiting the spread of communicable disease prone to epidemic occurrence is the control of movement of the people in the threatened areas. This is usually done in co-operation with the police.

It is seldom practicable to enforce a universal standstill order in an extensive area. Nor is it necessary. Control of movement is more acceptable to the people and is likely to be just as effective as the more rigorous standstill order. Under control travel may be made conditional upon the immunisation of intending travellers against the disease concerned, e.g. inoculation against cholera, vaccination against smallpox, inoculation against yellow fever or typhus fever, upon a disinfection of their clothing and baggage (typhus fever, plague, smallpox) or medical examination prior to the journey. Arrangements have to be made to enable intending travellers to have these measures carried out and a system of travel permits instituted by the Health Authority in collaboration with the police. Such permits are issued only to applicants who satisfy the requirements of the Sanitary Authority.

Carriers

One would think that the presence of a pathogenic organism in any part of the body would result either in the destruction of the organism or the injury of the tissues on which the organism was growing. But it often happens that a pathogenic organism can establish itself in the body of a perfectly healthy person and remain established there, often for long periods, without causing any impairment of the health of the person so infected. Such a person is known as a "carrier" and he may be very dangerous because, though he suffers no ill effects from his infection, and indeed may be quite ignorant of the fact that he is infected at all, he may spread the organism by his unhygienic habits and be the unsuspected cause of an outbreak of disease.

Since the carrier is apparently in perfect health his connection with outbreaks of disease originating from him can only be made by inference. For instance, a certain cook may occupy a number of posts, and in each household in which she works sporadic cases of typhoid fever occur. It may not be until some considerable time has elapsed that suspicion may be directed against her and so she may do a great deal of harm before she is discovered. Definite proof of the carrier state can only be obtained by special methods of examination directed to the discovery, in the carrier or in his excretions, of the organism concerned.

It is now the practice where means exist for carrying out the necessary procedure, to search for carriers in connection with certain of the communicable diseases. The diseases in which the

carrier state is common are cerebro-spinal fever the typhoid and paratyphoid fevers, diphtheria, the dysenteries and cholera.

In addition to the healthy carrier there is always a certain proportion of patients who harbour for some time after recovery the germs of the disease from which they have suffered. Such persons are known as convalescent carriers.

Carriers, whether convalescent or healthy seldom excrete continuously the germs they carry The excretion of germs is usually intermittent, periods of quiescence alternating with periods of excretion. This intermittent feature of the carrier state makes the detection of carriers sometimes very tedious if not impossible.

Parasitism and the Parasitic Diseases

One very interesting part of tropical work, though it adds a good deal to the difficulty of the subject, is the study and control of disease due to animal parasites. Parasitism occurs much more often in the tropics and exhibits a much greater variety of parasites than is found in the temperate regions of the earth. In the study of tropical hygiene the term parasite is given generally to an animal which lives inside or on the surface of the body of some other animal, known as the *host* of the parasite, and derives its nourishment either from the food eaten by the host, from the tissue fluids of the host or even from the tissues of the host. The essence of parasitism is therefore live and let live." There are parasites so well adapted to the hosts they live in that the host is unharmed by the parasite, and so long as the host lives so long will the parasite be able to fulfil the natural term of its existence. But in the forms of parasitism with which the Sanitary Authority has to deal the parasite is not so well adapted to the host as to live peacefully with it, and the degree of lack of adjustment is shown in the kind of disturbance produced in the host s economy by the parasite. This may be so great as to kill the host, in which event both the host and the parasite perish, because such parasitic animals have lost the power of being able to fend for themselves, and when their living food supply perishes they also must die.

So far as their manner of life is concerned, parasites are classified as *ecto-parasites* and *endo-parasites* The ecto-parasites are those which live on the surface of the host s body the endo-

parasites are those which pass their life, or part of it, inside the body of the host. The common ecto-parasites are the fleas, lice and ticks. They cause little damage in themselves, but where they are dangerous is in acting as transmitters of certain diseases. Lice transmit relapsing fever and typhus fever fleas, plague and ticks, relapsing fever

The endo-parasites and their behaviour furnish by far the most fascinating study in tropical hygiene. The principal phyla of animals whose members shew parasitism are the Protozoa and the helminths. Parasitism has caused profound structural changes in some of these animals, as it has also modified their behaviour in a remarkable way The parasitic worms, for instance have lost most of their digestive organs and, instead, have developed enormously their capacity to reproduce. The various changes of form and habit which animals undergo during their growth from the fertilised egg to the adult state are collectively known as the *life-history* or *life-cycle* of the animal and many parasitic animals have life histories which for variety and ingenuity are scarcely credible. Some parasites undergo a certain part of their life-history in one host, and another part in another The host in which the adult, or sexual forms of the parasite occur is known as the *definitive host* that in which the vegetative forms occur is known as the *intermediate host*

A remarkable thing about many of the parasitic animals is that they have two ways of reproducing their kind. One way is by a process of budding, common among plants but rare in animals, and the other way is by the union of special sexual cells containing the male and female elements resulting in the production of a fertilised egg. Usually those two processes of reproduction occur in different hosts, the budding, or *vegetative* form taking place in the intermediate host, while the sexual form occurs in the definitive host.

Another point of interest with regard to parasitic animals is that most parasites can subsist on one and one host only There are others which may be able to infect a number of hosts, but they are not numerous. Moreover the parasite can infect its appropriate host only at a definite stage of its life-history Should the host ingest or otherwise come into contact with its parasite at any other stage of the latter s life history than the infective one, the parasite cannot maintain itself in the body of the host and dies.

The Communicable Diseases

The communicable diseases are those diseases which spread from the infected to the healthy They are caused by some living organism which gains access to the tissues and they are the reaction made by the tissues of the body to the invading organism. The public health authority is largely occupied in the study and control of this group of diseases.

The study of the communicable diseases is known as *epidemiology* Many of the diseases in this group have a tendency to occur in large numbers of persons at a time. The simultaneous occurrence of a disease in a large number of persons in an area is known as an *epidemic* of the disease. When the disease occurs in epidemic form simultaneously in a number of countries it is known as a *pandemic* A pandemic is therefore a huge epidemic. When cases of a communicable disease occur in a community in small numbers and in separate places such cases are known as *sporadic* cases, and small outbreaks arising apparently spontaneously in different areas are known as sporadic outbreaks. When a communicable disease has taken hold in a country and appears in it more or less continually it is said to be *endemic* in that country

The communicable diseases may be grouped for study according to the cause, or according to the method of spread. But a word of caution is necessary here. When we talk of the method of spread of communicable diseases we do not, for the most part, refer to any observed fact, we refer to inference. The reason for this is that we cannot see the process of infection the organisms causing the communicable diseases are invisible to the naked eye. When we say that the spread of a disease is respiratory we really mean that the observed facts of the spread of infection amongst human beings are more in accordance with the hypothesis that the spread takes place from naso-pharynx to naso-pharynx than with any other hypothesis, e.g spread by drinking water by flies or by the excreta Subject to this important qualification we may for convenience, group our material for study according to the method of spread.

Group I

Diseases spread through the Excreta

Enteric Fever

The group of fevers comprising enteric or typhoid fever

and the paratyphoid fevers is very widespread. Those diseases occur more frequently in badly sanitated countries than in those in which the sanitation is good

Typhoid fever is caused by a bacillus known at the *Bact typhosus* The invasion of the body by the bacillus causes an acute infection which disables the patient by causing a continued fever lasting about four weeks, a typical skin eruption and bowel disorder generally manifested as diarrhœa

Incubation Period.—The incubation period varies between ten and fourteen days but it may be more or less.

Liability to Epidemic Spread —This disease is liable to produce epidemics, and it has caused large epidemics in the past. It is endemic in practically every country in the world.

Period of Infectivity of Patient —The patient is infectious all through his illness and, in a certain number of cases, during his convalescence.

Carrier State —Is common in typhoid fever

Channels of Entrance and Exit —Typhoid fever is contracted by the mouth. The bacilli are swallowed in food, drink or possibly dust. The bacilli leave the body of the patient—

(*a*) in the sputum when there is bronchitis or pneumonia as a complication

(*b*) in the fæces

(*c*) in the urine.

Methods of Spread.—If the possible methods of spread of typhoid fever are considered light will be thrown on the way the disease is contracted.

The patient is the focus of infection. He is excreting typhoid bacilli possibly in his sputum, certainly from time to time during his illness in his fæces or urine, or in both.

The sputum may infect feeding utensils and if these are used by other persons before they have been disinfected the person using the articles may contract the disease.

Persons kissing the patient may become infected

Sputum pots left lying about—or sputum exposed to the air—may be visited by flies, and the infection spread by them in visiting the food of other persons.

The improper disposal of infected fæces or urine i e. without disinfection, or without disposing of them in such a way as experience has shown to be preventive of the spread of the disease, is perhaps the commonest way in which typhoid fever

is spread. The excreta may be left exposed to flies, or they may be disposed of in a faulty manner i.e. thrown without previous disinfection into the pail latrine or into a pit latrine accessible to flies and cockroaches. The infected contents of the pail latrine may be used in a vegetable garden as manure and infection thus spread to such vegetable as lettuce or radishes which are habitually eaten raw. A defective pit latrine near a defective well *may cause infection to enter the well* and the washing of the patient's clothes on the well head may also be a means of contaminating the well and of causing a local water borne outbreak. In countries where there is a severe winter it has happened that where defective latrines were near a stream, the spring rains had washed pollution from the latrines into the stream and had caused an outbreak of typhoid fever in a community living at a distance below the point of pollution using the stream water for domestic purposes.

Prevention.—The patient should be isolated. Contacts should be inoculated against the disease and they should be kept under surveillance for three weeks if practicable.

An attempt should be made to ascertain where the patient caught the infection. For this purpose his movements during the month previous to his falling ill should be ascertained to find out whether he had visited an area in which the disease was present, whether he had visited any sick person or had attended a wake or a similar death rite. The inspector should also find out and report upon the water supply of the patient's household the milk supply and the general sanitary state of the premises with special reference to the arrangements made for the disposal of excreta and to the prevalence of flies. He should note whether *the premises are provided with a latrine and, if so* whether the latrine is habitually used or not. If the latrine is a pit latrine whether it is fly proof or not if a pail latrine whether the sanitary service is carried out regularly or is neglected. The *neighbouring* premises should also be visited to find out if there are other cases of the disease there, or if cases have occurred recently. Their sanitary state should also be noted, as in the case of the premises on which the patient fell ill.

The inspector should make a list of all persons who may be regarded as contacts. This list will include the persons living in the same house as the patient and those in the immediate vicinity. If he is entrusted with the surveillance of the contacts

he should keep a record of each visit made by them to the Sanitary Office, or if he visits the premises at specified times, of each occasion on which he sees them Failure of a contact to report should be immediately notified to the Medical Officer under whom the inspector is working

Should the patient be treated in his house the inspector must make sure that the nurse in charge of the patient has made the room suitable for the treatment of the case. All unnecessary furniture should be removed from the room. Fly screens should be affixed to the windows or failing this, means must be taken to prevent flies having access to clothing and utensils soiled by the patient s discharges. Arrangements should be made for the disinfection *in the patient s room itself* of all articles likely to be infected before they are sent out for cleansing There should also be a supply of disinfectant for the use of the nurse who should carefully wash and scrub the hands in disinfectant solution before leaving the patient s room. The nurse should receive protective inoculation against the disease.

Instruction should be given to the nurse in the proper method of disinfecting the fæces and urine of the patient and soiled articles of his bedding or clothing Visitors should preferably not be allowed in the sick room and they should certainly not be allowed to partake of food or drink in it. Kissing the patient and shaking hands with him should be forbidden.

Bacillary Dysentery

Bacillary dysentery is an acute disease caused by the invasion of the lining of the large intestine by the *B dysenteriæ* The disease produces fever a certain amount of poisoning of the system and an acute diarrhœa accompanied by severe griping pain, ineffectual straining at stool and the passage of mucus and blood by the rectum. The disease may be mild or extremely severe and fatal.

Incubation Period.—Short one to seven days.

Liability to Epidemic Spread.—Liable to produce epidemics. It has world-wide endemicity

Period of Infectivity of the Patient —The patient is infectious all through his illness.

Carrier State —Dysentery is one of the diseases in which the carrier state has been observed. The carrier state may last for years in a person otherwise apparently healthy

The methods of spread and the type of enquiry and action required for the control of this disease are practically identical with those of typhoid fever

Amœbic Dysentery

Amœbic dysentery is a chronic disease with a great tendency to relapse It is caused by infection of the wall of the large intestine by a protozoal parasite known as the *Entamœba histolytica*.

The disease is universal in the tropical zone and in the subtropics.

The incubation period of the disease is unknown, but it is thought to be at least several weeks.

Liability to Epidemic Spread.—The disease shows no sign of epidemicity an epidemic of dysentery is almost certainly an epidemic of bacillary dysentery not amœbic. Amœbic dysentery is typical of an insidious endemic disease.

Period of Infectivity of the Patient.—The patient is infectious so long as he is passing cysts (see below). This may be for years afterwards.

Carrier State —Is common and may last for years.

Life-history of the Entamœba histolytica —The active amœbæ live on the wall of the large intestine. They burrow into the mucous membrane and produce ulcers in it. After a time a number of these amœbæ which have been multiplying in the tissues of the intestinal wall reappear in the fæces and, having become spherical, develop a thick membrane round them. In this condition they are known as amœbic cysts. The cystic condition is the resting inactive condition of the amœba and the purpose of it is pretty much the same as the purpose of the seed of a plant, namely to disseminate the species. These cysts are passed out of the intestine in the fæces. They are invisible to the naked eye and require the use of the compound microscope for their discovery and study The thick membrane surrounding the amœba preserves it from drying and enables it to keep alive outside the human body for as long as ten days.

The infection is caught by the consumption of foodstuffs contaminated by viable cysts. The cysts are swallowed and in the small intestine they hatch into active amœbæ which, passing to the large intestine, attack the wall and begin the cycle again.

The methods of spread and of prevention are much the same as for bacillary dysentery Flies are often concerned in the spread of the disease

Asiatic Cholera

An acute infectious disease caused by infection with the V *Cholerae* or cholera vibrio—a bacterium. There is profuse purging and vomiting, muscular cramps, suppression of urine great collapse of the patient and a high mortality

Incubation Period.—Short two to five days.

Liability to Epidemic Spread—Great. In insanitary and backward countries it is the classical example of a widespread water borne epidemic. It is endemic in the Far East and India It is not now endemic in Europe, America Africa or Australia.

Period of Infectivity of Patient.—The patient is infectious throughout his illness and for a week or ten days after recovery

Carrier State—The carrier state occurs, but is not common.

Channels of Infection.—The patient or carrier is the source of infection. The patient excretes the germs of the disease in his vomit, stools, and, possibly also in his urine in convalescence. The carrier excretes the germs intermittently in the stools and urine. In the tropics this means that carriers may have the hands contaminated from time to time.

The vibrio can live in moist soil for many days, and in natural waters sometimes for months.

Method of Spread.—Epidemic Cholera. Water—contamination of water supplies by (*a*) throwing into them (rivers) corpses only partially cremated (*b*) by defæcating near the banks or actually in the stream (*c*) (wells) by washing the bedding and clothing of patients on the well-head (*d*) (wells) by maintaining defective pit latrines near shallow wells.

Sporadic Cholera Spread from patient (*a*) by flies (*b*) through defective night soil disposal (*c*) through the use of night soil as a fertiliser in market gardening

Prevention—Isolation of patient.

Preventive inoculation of all contacts against infection of the V *cholerae* (anti-cholera vaccine) or surveillance of the contacts for a week.

Prevention of fly-breeding

Purification of water supplies In villages pinking of wells (see p. 232).

Prohibition of the holding of fairs or festivals during the cholera season or alternatively making it compulsory for all participants to be inoculated against the disease. Inoculation of pilgrims before they go on pilgrimages to countries where the disease is endemic or liable to epidemic occurrence.

Undulant Fever

This is a specific disease caused by two nearly related organisms A micrococcus, *Brucella melitensis* and a bacillus, *Brucella abortus* Infection of man by these micro-organisms results in a long-continued fever skin rashes, enlargement of the spleen and great debility

The disease first became prominent in Malta and for a time it was known as Malta fever Recently it has been found to have a world-wide distribution.

So far as recent work shows there seem to be two strains the goat strain, *Br melitensis*, in which the disease is severe, and the cattle strain, *Br abortus* in which the disease is mild.

The infection occurs naturally in goats and cattle. It is excreted in the urine and milk of infected animals. Man contracts the infection through drinking contaminated milk or by the consumption of fresh butter cream and cheese made from contaminated milk.

In Malta the preventive measures recommended were as follows

A Measures relating to Goats.

1 The perambulation of goats through the streets should be strictly forbidden.

2 The branding of goats on the hoofs should be carried out, as in the case of cows.

3 The goats should be penned or housed as far as possible from human habitations.

4 Examination of goats suspected to be infected.

5 Examination before shipment of all goats intended for exportation.

6 Segregation of reacting goats for observation.

7 Destruction of goats shewing persistent infection.

8. Compensation to owners on two scales (*a*) while their goats are segregated, and (*b*) for goats destroyed.

B Measures relating to Milk Supplies

1 The establishment of large dairies or depots under Government control or supervision.

2. The transmission of the milk in sealed cans to proper dairies in the towns.

C. Other Measures relating to the Civil Population.

1 More strict notification.

2. Efforts should be made to extend the practice of having blood examinations made in cases of fever

3 Impress on sanitary inspectors the importance of their milk enquiries.

4 Educate the people by leaflets telling of the importance of preserving some degree of sanitation in their dwellings, the dangers of infected milk, need for milk sterilisation, etc.

5 Promiscuous micturition in the streets and roads should be prohibited, and a penalty imposed upon offenders.

6 Latrine accommodation should be provided for workmen employed in building operations.

D Measures applicable to the Services

1 With regard to the garrison, the isolation of Mediterranean Fever cases should be continued.

2. The entry of goats into barracks or other Government places should be strictly prohibited and they should not be allowed to be housed, nor should resting places be permitted to be established in the neighbourhood of such places.

3 Pending the possibility of obtaining absolutely safe milk, the use of goats milk, or its products, should be absolutely forbidden in any hospital, barracks, ship or other Government establishment.

4 The use of condensed or other forms of preserved milk should be continued in hospitals and barracks, including messes and other regimental institutes.

5 Continue the warning to soldiers and to soldiers families as to making use of goats or cows milk outside barracks or quarters.

The undulant fever due to *Br abortus* is a very much milder disease than that due to *Br melitensis.* For this reason it is frequently undiagnosed and the source of the infection not traced.

The preventive measures applicable are

(*a*) Inspection of cowkeepers and others employed in the milk trade.

(*b*) Detection and isolation of patients suffering from the disease.

(*c*) Pasteurisation of milk and the cooking of other dairy products such as cream and cheese before consumption unless these are made from pasteurised milk.

CHAPTER IV

WORM INFECTIONS SPREAD THROUGH THE EXCRETA

Hookworm Disease, or Ankylostomiasis

HOOKWORM disease is caused by the infestation of man by the parasitic round worm known as the hookworm. The disease is characterised by debility of the patient, progressive anæmia swellings of the feet, legs and face, and gradual exhaustion, perhaps leading to death. It is not a deadly disease but it owes its importance to the fact that it is extremely common in the tropics and sub-tropics, at least three-quarters of the inhabitants of those regions harbouring the parasites, and to the fact that it lowers the vitality of large numbers of people

Life-history of the Hookworm—Hookworms are small creatures. They measure about 8 mm. in length and about 0 3 mm. in thickness. They are cylindrical in shape and when recovered from the stools after the administration of the appropriate drugs, they are yellowish white in colour though they may shew longitudinal streaks of chocolate brown colour on account of the blood they have swallowed. Hookworms have a mouth adapted for sucking and it is armed either with teeth or with cutting plates, according to the species of the worm (Figs. 10 and 11).

The worms of both sexes live in the jejunum of man They attach themselves to the mucous membrane lining the bowel and by tearing the capillary vessels with their teeth or cutting plates they cause hæmorrhage. They feed on the blood. It is apparently their habit when feeding to change from place to place so that they cause a number of bleeding-points from which blood oozes for a considerable time after the worm has left them.

The females lay vast numbers of oval eggs, which pass out of the host's body in the fæces. The eggs are too small to be seen by the naked eye They require a microscope for their

Copulation takes place in the jejunum and thereafter the female worm produces a steady stream of eggs which mix with the intestinal contents of the host and find their way to the exterior in his fæces. Arrived at the exterior the eggs hatch into larvæ and the cycle begins once more.

The duration of life of the adult hookworm is unknown. Some observers reckon it in months others in years.

The complicated journey through the blood vessels and respiratory tract seems to be necessary for the development of the larval hookworm into an adult. If larval hookworms are swallowed on foodstuffs contaminated by fæcal material containing them the larvæ cannot apparently proceed straight to the jejunum and there undergo development. They must penetrate the mucous membrane of the mouth or stomach, gain the blood capillaries and undergo the same journey through the lungs as do those which enter by the skin.

Ankylostomiasis is a disease of the rural tropics. It is not nearly so common in cities and big towns which, by now have proper means for the disposal of excreta. It is a disease of populations whose members go barefoot and ease themselves on the surface of the ground. When once a person of this kind becomes infected with hookworms he very quickly re-infects himself, especially if he is in the habit of retiring to the same place to evacuate his bowel. Within a week he may render highly infective the ground he uses for this purpose and if he is barefoot he will become infected with numbers of larvæ every time he goes to stool.

Incubation Period.—It is not usual to speak of the incubation period of diseases other than the acute infectious diseases, but the term is a convenient one and will be used here to denote the time taken between the entry of the infectious agent (bacterium, virus, protozoon or helminth) and the appearance of signs of the disease. In hookworm disease we regard the occurrence of the hookworm eggs in the fæces as being a sign of infection. From the time the larvæ penetrate the skin to the occurrence of hook worm eggs in the fæces is about six weeks.

Liability to Epidemic Spread.—Hookworm disease does not cause epidemics. Epidemics only occur in the communicable diseases of bacterial, virus, or protozoal origin.

Endemicity.—The hookworm is endemic all through the tropics and sub-tropics. In temperate countries it occasionally

occurs in badly sanitated mines, and another name for hookworm disease is miners anaemia.

Period of Infectivity of the Patient.—Infection is seldom got from the patient commonly from contaminated ground or food. The patient can infect the soil so long as he is passing hookworm eggs in his stools and persists in defaecating on the surface of the ground. Most rural dwellers in the tropics and sub-tropics are continually excreting hookworm eggs and continually being re-infected.

Carrier State.—Enough has been said to show that the carrier state is the rule, not the exception that it is in the bacterial diseases.

Channels of Infection.—Faeces from the patient. Contaminated ground vegetables and possibly shallow wells. The principal way in which hookworm disease is contracted is through the skin of the feet or hands being brought into contact with contaminated soil.

Methods of spread have already been indicated.

Prevention.—The chain of infection—patient soil-skin of a healthy person—can be broken at any of the three links. Certain drugs can be given to the patients which cause the expulsion of the worms. When once a patient has been freed of his hookworms all he needs to do to prevent reinfection is to be careful that he eats only cooked food drinks only pure water always wears shoes out of doors and does not work with the soil. As most of the tropical peoples depend upon agriculture the last requirement is generally impossible, and since most of those exposed to infection cannot afford shoes the chances of their escaping re infection are very slight if treatment is the only measure which can be taken for the control of the disease.

The main measures on which the public health authorities depend for the control of hookworm disease in tropical and sub-tropical countries are, firstly a soil sanitation campaign, and secondly a treatment campaign. By soil sanitation is meant the sterilisation of infected soil and the prevention of further pollution of the soil by human excrement. The sterilisation of infected soil will take place naturally through the lapse of time because hookworm larvae cannot live for ever in the soil. The prevention of soil pollution means the construction of sanitary latrines and their habitual use by the people concerned. When once the rural population have gained the habit of defaecating only in a latrine a mass treatment campaign can be carried out

Copulation takes place in the jejunum and thereafter the female worm produces a steady stream of eggs which mix with the intestinal contents of the host and find their way to the exterior in his fæces. Arrived at the exterior the eggs hatch into larvæ and the cycle begins once more.

The duration of life of the adult hookworm is unknown. Some observers reckon it in months others in years.

The complicated journey through the blood vessels and respiratory tract seems to be necessary for the development of the larval hookworm into an adult. If larval hookworms are swallowed on foodstuffs contaminated by fæcal material containing them the larvæ cannot apparently proceed straight to the jejunum and there undergo development. They must penetrate the mucous membrane of the mouth or stomach, gain the blood capillaries and undergo the same journey through the lungs as do those which enter by the skin.

Ankylostomiasis is a disease of the rural tropics. It is not nearly so common in cities and big towns which, by now have proper means for the disposal of excreta. It is a disease of populations whose members go barefoot and ease themselves on the surface of the ground. When once a person of this kind becomes infected with hookworms he very quickly re-infects himself especially if he is in the habit of retiring to the same place to evacuate his bowel. Within a week he may render highly infective the ground he uses for this purpose and if he is barefoot he will become infected with numbers of larvæ every time he goes to stool.

Incubation Period.—It is not usual to speak of the incubation period of diseases other than the acute infectious diseases, but the term is a convenient one and will be used here to denote the time taken between the entry of the infectious agent (bacterium, virus, protozoon or helminth) and the appearance of signs of the disease. In hookworm disease we regard the occurrence of the hookworm eggs in the fæces as being a sign of infection. From the time the larvæ penetrate the skin to the occurrence of hookworm eggs in the fæces is about six weeks.

Liability to Epidemic Spread.—Hookworm disease does not cause epidemics. Epidemics only occur in the communicable diseases of bacterial, virus, or protozoal origin.

Endemicity.—The hookworm is endemic all through the tropics and sub-tropics. In temperate countries it occasionally

occurs in badly sanitated mines, and another name for hookworm disease is miners anæmia

Period of Infectivity of the Patient—Infection is seldom got from the patient commonly from contaminated ground, or food. The patient can infect the soil so long as he is passing hookworm eggs in his stools and persists in defæcating on the surface of the ground. Most rural dwellers in the tropics and sub-tropics are continually excreting hookworm eggs and continually being re-infected.

Carrier State—Enough has been said to show that the carrier state is the rule not the exception that it is in the bacterial diseases.

Channels of Infection—Fæces from the patient. Contaminated ground vegetables and possibly shallow wells. The principal way in which hookworm disease is contracted is through the skin of the feet or hands being brought into contact with contaminated soil.

Methods of spread have already been indicated.

Prevention—The chain of infection—patient soil-skin of a healthy person—can be broken at any of the three links. Certain drugs can be given to the patients which cause the expulsion of the worms. When once a patient has been freed of his hookworms all he needs to do to prevent reinfection is to be careful that he eats only cooked food drinks only pure water always wears shoes out of doors and does not work with the soil. As most of the tropical peoples depend upon agriculture the last requirement is generally impossible, and since most of those exposed to infection cannot afford shoes the chances of their escaping re-infection are very slight if treatment is the only measure which can be taken for the control of the disease.

The main measures on which the public health authorities depend for the control of hookworm disease in tropical and sub-tropical countries are, firstly a soil sanitation campaign, and secondly a treatment campaign. By soil sanitation is meant the sterilisation of infected soil and the prevention of further pollution of the soil by human excrement. The sterilisation of infected soil will take place naturally through the lapse of time because hookworm larvæ cannot live for ever in the soil. The prevention of soil pollution means the construction of sanitary latrines and their habitual use by the people concerned. When once the rural population have gained the habit of defæcating only in a latrine, a mass treatment campaign can be carried out

Copulation takes place in the jejunum and thereafter the female worm produces a steady stream of eggs which mix with the intestinal contents of the host and find their way to the exterior in his fæces. Arrived at the exterior the eggs hatch into larvæ and the cycle begins once more.

The duration of life of the adult hookworm is unknown. Some observers reckon it in months others in years.

The complicated journey through the blood-vessels and respiratory tract seems to be necessary for the development of the larval hookworm into an adult. If larval hookworms are swallowed on foodstuffs contaminated by fæcal material containing them the larvæ cannot apparently proceed straight to the jejunum and there undergo development. They must penetrate the mucous membrane of the mouth or stomach, gain the blood capillaries and undergo the same journey through the lungs as do those which enter by the skin.

Ankylostomiasis is a disease of the rural tropics. It is not nearly *so common in cities and big towns which*, by *now* have proper means for the disposal of excreta. It is a disease of populations whose members go barefoot and ease themselves on the surface of the ground. When once a person of this kind becomes infected with hookworms he very quickly re-infects himself, especially if he is in the habit of retiring to the same place to evacuate his bowel. Within a week he may render highly infective the ground he uses for this purpose and if he is barefoot he will become infected with numbers of larvæ every time he goes to stool.

Incubation Period.—It is not usual to speak of the incubation period of diseases other than the acute infectious diseases, but the term is a convenient one and will be used here to denote the time taken between the entry of the infectious agent (bacterium, virus, protozoon or helminth) and the appearance of signs of the disease. In hookworm disease we regard the occurrence of the hookworm eggs in the fæces as being a sign of infection. From the time the larvæ penetrate the skin to the occurrence of hook worm eggs in the fæces is about six weeks.

Liability to Epidemic Spread.—Hookworm disease does not cause epidemics. Epidemics only occur in the communicable diseases of bacterial, virus, or protozoal origin.

Endemicity.—The hookworm is endemic all through the tropics and sub-tropics. In temperate countries *it* occasionally

occurs in badly sanitated mines, and another name for hook worm disease is miners anaemia.

Period of Infectivity of the Patient.—Infection is seldom got from the patient commonly from contaminated ground, or food. The patient can infect the soil so long as he is passing hookworm eggs in his stools and persists in defaecating on the surface of the ground. Most rural dwellers in the tropics and sub-tropics are continually excreting hookworm eggs and continually being re-infected.

Carrier State.—Enough has been said to show that the carrier state is the rule not the exception that it is in the bacterial diseases.

Channels of Infection.—Faeces from the patient. Contaminated ground vegetables and possibly shallow wells. The principal way in which hookworm disease is contracted is through the skin of the feet or hands being brought into contact with contaminated soil.

Methods of spread have already been indicated.

Prevention.—The chain of infection—patient soil-skin of a healthy person—can be broken at any of the three links. Certain drugs can be given to the patients which cause the expulsion of the worms. When once a patient has been freed of his hook worms all he needs to do to prevent reinfection is to be careful that he eats only cooked food, drinks only pure water always wears shoes out of doors and does not work with the soil. As most of the tropical peoples depend upon agriculture, the last requirement is generally impossible, and since most of those exposed to infection cannot afford shoes the chances of their escaping re-infection are very slight if treatment is the only measure which can be taken for the control of the disease.

The main measures on which the public health authorities depend for the control of hookworm disease in tropical and sub-tropical countries are, firstly a soil sanitation campaign, and secondly a treatment campaign. By soil sanitation is meant the sterilisation of infected soil and the prevention of further pollution of the soil by human excrement. The sterilisation of infected soil will take place naturally through the lapse of time because hookworm larvae cannot live for ever in the soil. The prevention of soil pollution means the construction of sanitary latrines and their habitual use by the people concerned. When once the rural population have gained the habit of defaecating only in a latrine a mass treatment campaign can be carried out

Copulation takes place in the jejunum and thereafter the female worm produces a steady stream of eggs which mix with the intestinal contents of the host and find their way to the exterior in his fæces. Arrived at the exterior the eggs hatch into larvæ and the cycle begins once more.

The duration of life of the adult hookworm is unknown. Some observers reckon it in months others in years.

The complicated journey through the blood-vessels and respiratory tract seems to be necessary for the development of the larval hookworm into an adult. If larval hookworms are swallowed on foodstuffs contaminated by fæcal material containing them the larvæ cannot apparently proceed straight to the jejunum and there undergo development. They must penetrate the mucous membrane of the mouth or stomach gain the blood capillaries and undergo the same journey through the lungs as do those which enter by the skin.

Ankylostomiasis is a disease of the rural tropics. It is not nearly so common in cities and big towns which, by now have proper means for the disposal of excreta. It is a disease of populations whose members go barefoot and ease themselves on the surface of the ground. When once a person of this kind becomes infected with hookworms he very quickly re-infects himself, especially if he is in the habit of returing to the same place to evacuate his bowel. Within a week he may render highly infective the ground he uses for this purpose and if he is barefoot he will become infected with numbers of larvæ every time he goes to stool.

Incubation Period.—It is not usual to speak of the incubation period of diseases other than the acute infectious diseases, but the term is a convenient one and will be used here to denote the time taken between the entry of the infectious agent (bacterium, virus, protozoon or helminth) and the appearance of signs of the disease. In hookworm disease we regard the occurrence of the hookworm eggs in the fæces as being a sign of infection. From the time the larvæ penetrate the skin to the occurrence of hook worm eggs in the fæces is about six weeks.

Liability to Epidemic Spread.—Hookworm disease does not cause epidemics. Epidemics only occur in the communicable diseases of bacterial, virus, or protozoal origin.

Endemicity—The hookworm is endemic all through the tropics and sub-tropics. In temperate countries it occasionally

occurs in badly sanitated mines, and another name for hook worm disease is miners anæmia

Period of Infectivity of the Patient—Infection is seldom got from the patient commonly from contaminated ground or food. The patient can infect the soil so long as he is passing bookworm eggs in his stools and persists in defæcating on the surface of the ground. Most rural dwellers in the tropics and sub-tropics are continually excreting hookworm eggs and con tinually being re-infected

Carrier State—Enough has been said to show that the carrier state is the rule, not the exception that it is in the bacterial diseases

Channels of Infection—Fæces from the patient. Contamin ated ground vegetables and possibly shallow wells. The principal way in which hookworm disease is contracted is through the skin of the feet or hands being brought into contact with contaminated soil

Methods of spread have already been indicated.

Prevention.—The chain of infection—patient-soil-skin of a healthy person—can be broken at any of the three links. Certain drugs can be given to the patients which cause the expulsion of the worms. When once a patient has been freed of his hook worms all he needs to do to prevent reinfection is to be careful that he eats only cooked food, drinks only pure water always wears shoes out of doors and does not work with the soil. As most of the tropical peoples depend upon agriculture the last requirement is generally impossible, and since most of those exposed to infection cannot afford shoes the chances of their escaping re-infection are very slight if treatment is the only measure which can be taken for the control of the disease.

The main measures on which the public health authorities depend for the control of hookworm disease in tropical and sub-tropical countries are, firstly a soil sanitation campaign, and secondly a treatment campaign. By soil sanitation is meant the sterilisation of infected soil and the prevention of further pollution of the soil by human excrement. The sterilisation of infected soil will take place naturally through the lapse of time because hookworm larvæ cannot live for ever in the soil. The prevention of soil pollution means the construction of sanitary latrines and their habitual use by the people concerned. When once the rural population have gained the habit of defæcating only in a latrine a mass treatment campaign can be carried out

with some prospect of permanent success. In practice it is found most difficult to persuade the population of the rural tropics to construct and habitually use latrines. A treatment campaign is usually undertaken concurrently with the attempt to sanitate the area in order to give the patients the benefit of treatment and to give an opportunity of explaining to them how the disease is spread and how easily it can be brought under control if only they will give up the habit of easing themselves on the bare ground. Owing to a number of causes, hookworm infection is still a grave problem in tropical countries and as its control depends upon the formation of new habits and the sacrifice of habits which so far seem to be ineradicable it is likely to continue to be one of the principal causes of inefficiency in these regions for a considerable time to come.

Schistosomiasis

Schistosomiasis is the name given to a group of diseases caused by certain parasitic flat worms which live in the veins of the portal system of man.

There are three main types of the disease each caused by a different parasite. One, the urinary type, is caused by *Schistosoma hæmatobium* the other the rectal type, by *S mansoni*, and the third, the dropsical type, by *S japonicum*. The worms are very tiny e.g 1 to 1 5 cm. long and 1 mm. in thickness. The females are longer and more slender than the males.

The general life history of the parasite may be first considered as a knowledge of it will enable the reader to understand the points in the epidemiology of the disease.

The peculiarity of the class of parasitic worms in which the Schistosome worms are grouped is that they have two entirely different methods of reproduction. The adult worms in which the sexes are distinct live in the veins of the warm-blooded host. There they copulate and the females lay vast numbers of eggs in the blood-stream which, in some peculiar way at present unknown, can make their way out of the small veins of the bladder and intestine into the cavity of these organs. There they mingle with the urine or fæces as the case may be, and are expelled by the host in the act of urination or defæcation. Should the excrement be voided on the surface of the ground the eggs die in about a fortnight. But if the eggs should reach water they almost immediately hatch into a microscopic creature which

leaves the egg and swims about in the water. The larval worm swims by means of cilia and it is known as a *miracidium*. The life of the miracidium is about twenty four hours. If it is to continue its existence it must, within this time, find the fresh water snail in which it passes the next stage of its growth, otherwise it dies. It cannot infect man or any other vertebrate host of the adult worm. If the water should happen to contain

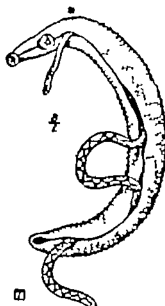


Fig. 12.—*S. hæmatobium*. Male and female.
The male is the larger worm, the female lies in a groove on the ventral surface of the male.

(*Castellani and Chalmers.*)

snails of the type suited to the further development of the miracidium (pl. miracidia) the miracidia bore through the tissues of the "foot" of the snail and eventually find their way to its liver. There they come to rest and become completely re-organised into hollow sausage-shaped bodies, on the inner surface of whose walls small buds appear. These buds eventually develop into small creatures not unlike microscopic tadpoles. They are known as *cercariæ*. When they are fully grown they make their way out of the snail and swim about in the water. If an infected snail is kept in water in a test tube the cercariæ which

emerge from it can just be seen by the naked eye as very tiny glistening specks moving in the water They swim up to the surface vigorously and then rest, and gradually sink by their own weight, until another wriggle sends them up again. The cercaria is the form of the worm which is infective to man. Its life is short—only thirty-six hours. If during its lifetime it comes into contact with a human being wading or bathing in the water in which it is swimming, it pierces the skin or mucous membrane with which it comes into contact and so gains the tissues of the host. It eventually arrives at the portal system of veins, where it settles down and develops into an adult.

Urinary Schistosomiasis

The urinary type of schistosomiasis is much more widespread than the others. In this type the eggs reach the urinary bladder of the host and they cause inflammation of the bladder and the appearance of blood in the urine. The appearance of blood in the urine is usually the first sign to the patient that he is infected. Sometimes the eggs may pass into the rectum. Ulceration of the viscera, abscess formation, and other severe injuries may be caused by this worm.

The *incubation period* of this disease is about three to six weeks.

Liability to Epidemic Spread.—It is not an infection which may be epidemic in the usual sense. It is strictly an endemic infection, and is only found endemic in areas inhabited by the snails which act as what are known as the intermediate hosts of the parasite, i.e. in which the miracidia can develop into cercariæ. Such areas are to be found in Africa, Mesopotamia, India, Siam, Western Australia, Mauritius, Madagascar and Reunion.

Period of Infectivity of the Patient.—The life of the adult worm is measured in years. Patients have been known to go on excreting the eggs for years after they have left the endemic area.

Carrier State.—See above. Man appears to be the only natural definitive host of the parasite, though monkeys, mice white rats and guinea-pigs can be artificially infected with it.

Channels of Infection.—Infection depends upon water In the absence of water the eggs cannot hatch. It also depends upon the particular snail which acts as the *intermediate host*. If the snail does not occur in the water in which the miracidia hatch they die.

Infection of man is usually contracted through the skin, either in wading washing or bathing

Prevention.—In countries where urinary schistosomiasis is endemic we know that there must be certain conditions—

(*a*) streams, canals, or ponds, harbouring a certain kind of water snail

(*b*) persons infected with the disease

(*c*) a population which habitually pollutes with excrement the waters in the vicinity

The preventive campaign aims at attack on the parasite and on the intermediate host.

The attack on the parasite is carried out by means of a treatment campaign effected either by travelling or fixed dispensaries. As many patients as possible are treated for the disease until they are cured. While the treatment campaign is being made, lectures are given during which is explained the life-history of the parasite and how the disease spreads. Emphasis is laid on the importance of the avoidance of polluting water with excreta, especially with the urine. An endeavour is made to induce the population to construct latrines and to use them habitually

The intermediate host, the snail, may be attacked only with difficulty As a first step, the habits of the snail require to be studied together with its distribution, breeding season, and food material. It may be found that the snail cannot survive drying, so that if the disease is associated with a system of irrigation, it may be possible to kill large numbers of the snails concerned by drying out the canals in which they live. This has been suggested as a preventive measure in Egypt.

The cercariae have been suggested for attack by the addition to the infected water of chemicals known to kill them. This is usually quite impracticable on a large scale, and on the kind of water by which the disease is spread. Schistosomiasis is not a disease of cities which have a sanitary water supply It is a disease of rural areas whose population depend upon surface waters for their supply

Intestinal Schistosomiasis

The intestinal form of schistosomiasis has the same epidemiological characters as has the Urinary The distribution of the disease is rather different. It is endemic in tropical Africa tropical South America and in certain of the West Indian Islands. The prevention of this form rests on the same measures as have already been noted in discussing the urinary form.

The Dropsical or Far Eastern Type

This type is due to a Schistosome worm which is limited in distribution to the Far East. The endemic areas are to be found only in Japan, China and the Philippine Islands, in the rice growing parts of these countries.

An important difference between *S japonicum* and the other two Schistosomes is that in nature it has more than one definitive host. *S hæmatobium* and *mansoni* have only man as their natural definitive host so far as we know The problem of their control therefore centres largely around man himself

It is otherwise with *S japonicum* which, in addition to man, is found to occur in nature in cows, horses, goats and pigs, dogs and cats. With such a large number of definitive hosts control of the infection is quite impossible and the fact that the cultivation of rice has to be carried out under conditions which preclude the adoption of protective measures makes the problem almost hopeless.

Tapeworm Infection

The tapeworms commonly met with practically all over the globe, namely *Tænia solium*, the pig tapeworm, and *Tænia saginata*, the beef tapeworm, are parasitic flat worms having small heads and long segmented bodies. The head or *scolex* is a rounded structure about a millimetre in diameter and from it extends the neck which merges into the body The body or *strobila* is composed of a number of segments known as *proglottides*. At the fore part of the worm the proglottides are small, but they gradually increase in size towards the hinder end. The proglottides at the end of the worm are about 12 mm. long, by 6 mm. broad. The whole worm may measure anything up to 10 metres in length, though the pork tapeworm, *T solium* is usually the shorter of the two and does not normally exceed 4 or 5 metres.

In the parasitic round worms, such as the hookworm, the sexes are separate individuals. The two cestodes we are now considering are quite different in that male and female sexual organs occur in the same individual. An individual of this kind is known as an *hermaphrodite*

The growth of the worm takes place just behind the head, at the end of the neck. Here new segments are being constantly formed which push their predecessors farther away from the growing-point. In the maturing segments there develop the

male and female genital apparatus and as the segments become mature the ova which have been developed in the ovary become fertilised by the spermatozoa which have become developed in the testes, these different sexual organs occurring in the same segment. When the ova become fertilised a new organ, the uterus, begins to grow and in its growth it absorbs the ovary and testes which are no longer necessary Eventually the segment or proglottis becomes merely a structure holding a uterus filled with fertilised eggs.

The lower end of a tapeworm is thus composed of a series of ripe segments all containing fertilised eggs. From time to time a number of these segments break off from the parent worm and they either make their way out through the anus of the host by their own movement or are extruded from the gut when the host goes to stool. They have a very limited power of movement, and they soon die when they leave the body of the host.

Further development depends on whether the eggs can find their way into the alimentary canal of another warm blooded host the pig in the case of *T solium*, and the ox in the case of *T saginata*. Should the suitable host swallow living eggs the embryos hatch out of them and pass through the wall of its alimentary canal and enter its capillary blood vessels. In the blood-stream they are carried to the muscles where they develop into little bladder or sausage-shaped bodies some 5 to 10 mm. long and 2 or 3 mm. thick. They are full of fluid and contain a miniature head and neck. When pork or beef is infected with these structures, which can easily be seen by the naked eye as small, greyish, translucent pock like bodies, it is known as measly beef or measly pork as the case may be, the "measles being the larval tapeworms. When man eats measly beef or pork, raw or cooked insufficiently to kill the *cysticerci*, as these larval forms are called, the bladder is dissolved by the gastric juice and the head and neck are liberated into the stomach contents. They pass down into the intestine in the normal course of digestion the head attaches itself to the intestinal wall and the proglottides begin to grow from the neck until the worm attains its adult form again.

Of these worms, *T solium* is the more dangerous to man because he may not only act as the definitive host but also as the intermediate host. Whether or not a human being infected with *T solium* can become infected with the eggs of his own parasite

is doubtful. It is extremely unlikely, because before the eggs can scatter the ripe proglottis of the worm containing them must die and decompose. Infection with the eggs of *T solium* is much more likely to be conveyed to man on food contaminated with old and dried fæces or with dust containing the eggs. In man the cysticerci of *T solium* cause acute pains in the muscles often ascribed to rheumatism. If the cysticerci should develop in the brain the patient may suffer from fits.

The prevention of these cestode infections lies in the following measures

(*a*) The treatment of persons infected with tapeworms.

(*b*) The use of sanitary means of the disposal of night soil in infested areas so as to prevent cattle and pigs from becoming infected.

(*c*) The inspection of meat before it is sold, and condemnation of infected carcases.

(*d*) The thorough cooking of beef and pork before it is eaten.

(*e*) Storing meat and pork in cold storage for six weeks will kill all the cysticerci in it.

CHAPTER V

THE COMMUNICABLE DISEASES

GROUP II

Diseases spread from Discharges from the Mouth and Nose

Tuberculosis

TUBERCULOSIS is an infection caused by a bacillus, the *B tuberculosus.* Invasion by the bacillus causes chronic abscess formation and destruction of tissue, the appearance of discharging sinuses, intoxication of the patient, fever and exhaustion. The disease is not confined to man it affects cattle, birds and other animals.

There are two main types of infection in man, the human and the bovine. The human type is caused by the tubercle bacillus that infects man. This bacillus seems to confine its attack to the respiratory system and cause the disease known as pulmonary tuberculosis or consumption The bovine type of bacillus affects cattle and when man becomes infected with it the principal structures attacked are the alimentary canal, the bones and joints.

PULMONARY TUBERCULOSIS

This is caused by the human type of tubercle bacillus and is spread from man to man. The bacillus causes inflammation of the lung, followed by abscess formation, spitting of blood, discharge of dead tissue and tubercle bacilli in the sputum, and, since much of this material is swallowed by the patient, the bacilli are excreted also in the fæces.

In Europe the disease tends to run a long, slow course, but in the tropics the tendency is for it to be acute and in some areas it is very rapidly fatal.

Incubation Period.—The incubation period is unknown. The infection may be dormant for years before it begins to shew signs in the patient.

Liability to Epidemic Spread.—It is not liable to epidemic spread. It is endemic all over the globe.

Period of Infectivity of the Patient.—To begin with, a patient infected with pulmonary tuberculosis and manifestly ill may not be infectious because the disease has not yet found its way to the surface. In this stage it is known as "closed tuberculosis" When, however the tissues begin to break down and reach the surface (open tuberculosis) the bacilli are generally to be found in the debris coughed up by the patient. He is infectious so long as this is happening

Carrier State.—This term is not usually applied to tuberculosis, but it is clear that if a person is suffering from open tuberculosis and his illness is not diagnosed he may be regarded as a carrier

Channels of Infection.—From the patient in his sputum and fæces. By far the most dangerous is the sputum, because the tubercle bacillus may remain alive for a long time in dried sputum, and in contaminated dust. Children are thought to contract the infection through dust from the room of a patient living in the same house.

Methods of Spread.—*Droplet infection.* When a person coughs or sneezes he expels together with air a spray of minute drops of moisture. If he is suffering from one of the diseases spread through the discharges from the nose and mouth the virus is generally contained in such droplets and infection spread in this way is known as *droplet infection.* The most dangerous droplet infection is pneumonic plague (see p. 72) Pulmonary tuberculosis is also spread in this way

Dried sputum. Moist sputum is not usually dangerous unless is happens to contaminate food or drink or the utensils used by others during meals. But when the sputum dries it breaks up into highly infectious dust, which, on being breathed by others, may infect them.

Moist sputum may be visited by flies and carried to foodstuffs by them.

Tuberculosis is not usually regarded as a water borne infection, but it may be spread by milk if the milker happens to suffer from open tuberculosis (see Diphtheria, p 67).

Prevention.

(*a*) Isolation of the patient.

(*b*) Disinfection of the sputum (see p. 158).

(c) Thorough disinfection of room formerly occupied by the patient.

(d) Damping the floor of the room occupied by the patient before sweeping it out daily and burning the sweepings.

(e) Prevention of overcrowding in houses occupied by patients.

(f) Medical surveillance of workers employed in dusty occupations, e.g. mining and spinning, and in handling foodstuffs.

(g) Detection and treatment of early cases by means of the establishment of Dispensaries.

(h) Prohibition of indiscriminate spitting.

Bovine Tuberculosis

A disease of cattle in which any tissue of the animal may be affected. Bovine tuberculosis in man and domestic animals attacks first the lymphatic glands and generally spreads in the body through the lymphatic vessels. Bovine tuberculosis may be contracted by man by drinking milk from tuberculous cows or by consuming insufficiently cooked flesh of animals suffering from the disease. Pork and beef are liable to carry the infection. Mutton, goats and fowls are not generally regarded as being dangerous in this respect.

Infected cows excrete tubercle bacilli in their milk.

Incubation Period.—Unknown.

Liability to Epidemic Spread.—Not liable. Bovine tuberculosis is world-wide.

Carrier State.—The infected cow may be regarded as the carrier.

Channels of Infection.—Through uncooked milk, butter or cheese, beef, veal or pork.

Methods of Spread.—Consumption of the raw or insufficiently cooked foodstuffs mentioned above.

Prevention.

(a) Inspection of dairy cattle to ensure that they are being properly housed and pastured (see p. 214).

(b) Testing the dairy cattle by means of the tuberculin test, and the destruction of cattle reacting positively to the test.

(c) The routine bacteriological examination of dairy products.

(d) The inspection of meat sold for human consumption.

The Tuberculin Test

Tuberculin is the concentrated filtered broth in which tubercle bacilli have been growing for six to eight weeks. It contains

about 50 per cent. glycerine and the toxins produced by the growth and disintegration of the bacilli. It does not contain any bacilli because these have been removed from it in the process of filtration. It is generally known as Koch's old, or original tuberculin.

When a small quantity say 0·4 c.c., of old tuberculin is injected subcutaneously into a healthy cow the animal suffers no discomfort or appreciable rise of temperature. If, however the animal is tuberculous, a reaction follows the injection. This reaction is shewn by the occurrence of fever which passes off within twenty four hours.

The tuberculin test is made in cattle as follows when the *subcutaneous method is used.*

The animals are kept in their stalls for a day or two previous to the test. The temperature of each animal to be tested is taken in the rectum at least twice, at intervals of three hours, and the temperature is recorded (the normal rectal temperature of a cow is between 101 and 102° F.) A sterile hypodermic syringe is used for the injection, which is generally made just behind the scapulæ. Before the injection the hair over the site of the injection is clipped and the skin carefully washed with a *5 per cent.* solution of carbolic acid or other suitable antiseptic. 0·4 c.c. Koch's old tuberculin diluted with sterile water until it measures 4 c.c. is injected under the skin. The most convenient time to make the injection is in the evening

The temperature is taken nine hours after the injection and thereafter at three-hourly intervals up to the eighteenth hour after If there is no fever at this time the cow is regarded as being free from tuberculosis. *If the temperature shews an upward* tendency the observations are continued until the temperature begins to fall.

A positive reaction is shewn by a rise of temperature of 2°—3° F in twelve hours, passing off after about twenty-four hours. Animals shewing this reaction are separated from the rest of the herd. They are not even allowed on the same grazing ground. They are generally destroyed, compensation being paid to the owners.

The test is not applied to cattle which are clearly suffering from tuberculosis to cattle which are suffering from fever due to some other cause, or to cows within a few days before or after calving In such cases the test is postponed until the animal is apparently healthy again.

Old, emaciated animals, and animals which have been tested before are given double the dose of old tuberculin specified above.

The subcutaneous test is not the only one which may be used. The tuberculin may be injected into—not under—the skin, or it may be dropped into the eye. In England a combination of the two tests is recommended. A sensitising injection of 0 1 c.c. of the undiluted tuberculin is made into the skin on a shaved area on the side of the neck of the animal and at the same time one drop of the undiluted tuberculin is instilled into one eye. Some three days later the same quantity of the tuberculin is injected into the skin at the same place as the former injection was made, and 2 5 drops of tuberculin are instilled into the eye.

A positive reaction is shewn by a thickening of the skin fold at the site of the injection. In non-tuberculous animals the thickening of the skin fold is very slight after the first injection and is unaltered after the second. In tuberculous animals the thickness after the first injection is 7 17 mm., twenty four hours after the second injection it is 13-40 mm. and forty-eight hours afterwards it may have increased by 7 79 mm. The thickness of the skin is measured with a pair of callipers as it is grasped between the thumb and index finger In addition to the increase in thickness in the skin fold, the swelling in tuberculous animals is soft and tender in healthy animals cool, firm and insensitive. A positive ophthalmic reaction is the occurrence of an acute inflammation of the eye and the appearance of pus in it.

Diphtheria

Diphtheria is an acute infectious disease caused by a bacillus known colloquially as the Diphtheria bacillus, which invades the body and causes the formation of false membranes and a profound toxaemia.

The disease most commonly attacks the upper respiratory tract, i.e. the larynx, the throat, and the nose, but it may also occur in wounds which happen to become infected, and in women and girls it may occur in the vagina.

The bacilli do not wander from the point of invasion. They remain on the surface and stimulate a great outpouring of serum which clots and forms a tough adherent skin known as the false membrane. A powerful exo-toxin is given off by the bacilli. The toxin circulates in the blood and causes paralysis of various parts of the body Diphtheria is a common disease of children in

temperate climates, and in cold countries In the tropics it does not seem to be so severe as it is elsewhere, nor is it so common.

The incubation period is short one to two to seven days—usually two.

Liability to Epidemic Spread.—The disease shews a tendency to epidemic occurrence in a susceptible population. It is endemic all over the world.

Period of Infectivity of the Patient.—The patient is infectious all through his illness.

Carrier State.—This is common in diphtheria. When an epidemic is investigated, or contacts are being examined, it is of common occurrence to discover healthy persons who harbour virulent diphtheria bacilli in the nose or mouth. These have picked up their infection from a patient, a convalescent or another carrier

Channels of Infection—The bacillus is discharged in the saliva or nasal mucus of the patient or carrier or in the discharges from infected wounds or other infected regions of the body Droplet *infection is common. It may be transmitted* from one person to another in coughing sneezing, kissing and even speaking Among children the most common paths of infection are toys, pencils, food, fingers, cups, or handkerchiefs used by an infected child. The habit of putting articles in the mouth, so common in children, is the principal reason why these articles are so dangerous.

A carrier employed in a dairy may infect the milk by coughing into it or by spitting on his hands to lubricate the teats of the cow while milking, and thus cause a milk-borne outbreak.

Domestic animals play little or no part in the spread of diphtheria.

Prevention.—The prevention of the disease rests on the following measures:

(*a*) Isolation of the patients. Detection of fresh cases and their isolation.

(*b*) Examination of contacts for the detection of carriers.

(*c*) Surveillance of contacts.

(*d*) Detection of susceptible persons by means of the Schick reaction.

(*e*) Immunising *susceptible persons by means of a series of* injections of diphtheria toxin modified either by admixture with anti toxin or by chemical treatment

Disinfection.—The disinfection of all articles likely to be contaminated by patients is necessary if the patient is isolated at home.

The proper control of diphtheria, like many other epidemic diseases, requires a well trained and equipped Laboratory Staff

The Schick Test

The Schick test depends upon the fact that when a minute dose of diphtheria toxin is injected into, not under the skin of a susceptible person it will produce an inflammatory reaction which is shewn by the occurrence, after twenty four to forty eight hours, of redness round the place where the injection was made. The reaction slowly disappears, leaving a definite area of scaly slightly pigmented skin. It has been found that when this test is made on a batch of schoolchildren only a certain proportion of them react to the test. The others have already enough anti toxin circulating in their blood to neutralise the injected toxin. If an epidemic should break out these children are unlikely to become infected, while those without a natural supply of anti toxin are most likely to suffer The immunity of such children may be stimulated by the subcutaneous injection of a mixture of toxin-anti-toxin, or of toxin which has been made harmless by treatment with chemicals without at the same time destroying its property of stimulating the production of anti-toxin by the person under treatment. This method of diphtheria control is now widely used in Europe and America where it has given remarkably good results

Cerebro-Spinal Fever

This is a disease caused by a diplococcus known as the meningococcus. The patient suffers from fever rash and a great variety of nervous symptoms. It is very fatal in the absence of treatment.

Incubation Period.—Short two to ten days.

Liability to Epidemic Spread.—It shews great liability to spread at certain times of the year Cold weather favours its occurrence. It occurs most typically in the form of localised outbreaks amongst bodies of people who are in fairly close association, e.g troops, inmates of institutions such as jails or mental hospitals, mine-workers, and the crews of ships.

It seems to be world-wide.

Period of Infectivity of the Patient.—The meningococcus can generally be isolated from the naso-pharynx of the patient during the first week of the disease. Thereafter it disappears in most cases.

Carrier State.—The disease is most likely spread by mild cases of the disease which have not been recognised as suffering from cerebro-spinal fever and by carriers. The carrier state is very common in this disease, but most carriers do *not* harbour the coccus long.

Prevention.—The disease is most difficult to control because of the large numbers of carriers associated with every outbreak. The only practicable measures are the isolation of patients, and, possibly control of movement.

Scarlet Fever

Scarlet fever is an acute infectious disease in which the patient suffers from fever sore throat, and a typical skin rash. The cause is a micrococcus known as a streptococcus.

Incubation Period.—Short two to four days.

Liability to Epidemic Spread.—Very liable. Large outbreaks are common in children under fifteen years at certain seasons of the year The disease occurs all over the world, but its severity seems to decline the nearer we get to the equator It is uncommon in the tropics and the sub-tropics, and when it does occur it is generally very mild. Occasionally however as in *South China it may be severe in type and epidemic in character* The disease is important because of its complications, the commonest and most serious of which is inflammation of the ear Inflammation of the kidney may also be a serious complication.

Period of Infectivity of the Patient—The patient is most infectious during the incubation period of the disease. Infectivity disappears quickly with the disappearance of the rash, if there are no morbid discharges from the ears or nose. Most cases are not infectious after four weeks unless there are discharges from the ears or nose.

Channels of Infection.—The patient is the chief source of infection. The *streptococci are found in the throat*, and they may be discharged by the patient as a droplet infection while sneezing or coughing

Eating utensils used by the patient may spread the disease and books have also been suspected. Dressings contaminated with discharges from the ears or nose may infect milk by way of flies.

There is a form of scarlet fever known as the Hendon Disease which was traced to contaminated milk from cows which had ulcerated teats.

Prevention.

(*a*) Isolation of patients.

(*b*) Observation of contacts.

(*c*) Disinfection of all articles used by patients.

Lobar Pneumonia

In this disease the patient becomes infected with a small bacterium known as the pneumococcus which sets up an acute inflammation of the lung The disease is marked by high fever difficulty in breathing and great strain on the heart. Death may occur suddenly from heart failure.

Incubation Period.—Short two to five days.

Liability to Epidemic Spread.—In the general population pneumonia does not usually appear in epidemic form. But where numbers of human beings are living in close proximity to one another under conditions which favour temporary or permanent lowering of resistance, such as labour gangs living in compounds, the disease may assume epidemic form and cause much loss of life and great disorganisation in the operations of the employers of the labourers. The disease occurs all over the world.

Period of Infectivity of the Patient.—The patient is infectious all through his illness.

Carrier State.—Most healthy persons harbour pneumococci in their mouth and nose. What makes the pneumococcus assume toxicity is not known.

Channels of Infection.—The infection is contracted either by a sudden lowering of the resistance of the patient, making him susceptible to infection by his own strain of pneumococcus, or as a droplet infection from the respiratory discharges of a person suffering from the disease.

Prevention.—Here we will concern ourselves merely with the prevention of pneumonia in labour camps and compounds. Under existing conditions the control of this disease in the general population is practically impossible.

In considering pneumonia in relation to compounds the following should be kept in mind

1 Pneumonia is a disease which affects especially newcomers to the compound.

2. The outbreak of the disease in new-comers will almost invariably affect the older residents at a later date unless steps are taken to prevent this.

3 The continued arrival of new-comers may keep going in a compound an outbreak of pneumonia which might have died out completely had no new-comers been admitted.

4 Droplet infection is the mode of spread when the disease is allowed to assume epidemic form.

The measures applicable to the control of pneumonia in compounds are therefore as follows

(a) Housing the inhabitants in rooms rather than in barracks. The rooms or huts should be of such a size that no more than four persons are housed in each. In such dwellings, occupied by only four persons, a floor space of 30 square feet per head is adequate, and a cubic capacity of 250 cubic feet per head sufficient. In designing or assessing huts with reference to these figures it is important to take into account the height of the walls. Brick rooms should have walls at least 8 feet high and the cubic capacity of the room should be ascertained with reference to this height space above it being disregarded. A grass hut may have smaller dimensions than a brick or stone structure because the walls and roof are much more permeable to air

(b) *Ensuring adequate ventilation of the huts and rooms.*

(c) Avoidance of dust in the compound.

(d) Early removal of cases of the disease to hospital.

(e) Throwing infected huts or rooms out of occupation for a fortnight. On the removal of the patient, the hut is evacuated, its whole contents thoroughly disinfected, and it is opened up and aired daily for a fortnight before reoccupation is allowed.

(f) Daily medical examination of all inhabitants of the compound so as to detect as soon as possible all those suffering from the disease.

(g) Protection of the inhabitants by vaccinating them with vaccines made from the same strains of pneumococci as those causing the disease.

Pneumonic Plague

Pneumonic plague is an acute and fatal disease caused by the *P pestis* occurring during outbreaks of bubonic plague (see p 120) in certain parts of the world. When once patients begin to suffer from pneumonic plague the disease spreads in epidemic form

from man to man with the same rapidity as influenza. It is practically invariably fatal.

Incubation Period.—Rarely exceeds six days.

Liability to Epidemic Spread.—In certain parts of the world notably Manchuria, huge epidemics have occurred from time to time.

Period of Infectivity of Patient.—The patient is infectious on the onset of symptoms and thereafter throughout his illness.

Carrier State—Does not exist in the strict sense of the term

Channels of Infection.—From the patient in his sputum Infected dust, clothing and other articles.

Method of Spread.—Droplet infection. It is the most dangerous droplet infection known. The cough of patients is the most usual way for the spread of the infection. Other means are of relatively little importance.

Prevention.

(*a*) Early detection of cases and isolation of patients.

(*b*) Isolation of contacts five days observation.

(*c*) Preventive inoculation of the population with anti plague vaccine.

(*d*) Thorough disinfection of patients premises.

(*e*) Cremation of corpses.

(*f*) Prevention of overcrowding.

(*g*) Temporary evacuation of infected areas.

Personal prophylaxis. Pneumonic plague is so infectious that special measures of protection must be taken by the health staff engaged on house-to-house investigation. The most important of these is the protection of the mouth and nose by the wearing of a mask. The mask designed by Dr Wu Lien Teh and found to be effective consists of a pad of absorbent cotton wool ½ inch thick, 4 inches wide and 6 inches long enclosed between two layers of surgical gauze each 2 feet 6 inches long The pad is fixed in position in the middle of the strips by a few stitches. The ends of the gauze are split down the middle for 15 inches so as to make two tails. In wearing the mask the pad is placed over the mouth and nose and is fixed in position by carrying back over the ears the free ends of the gauze. The upper tails are carried over the ears and knotted together at the back of the head, the lower tails are carried below the ears and are similarly knotted together As an additional protection small pieces of cotton wool may be plugged between the mask and the skin

at either side of the nose where the pad tends to gape. Goggles are worn to protect the eyes and washable overalls to protect the clothing Gum boots and rubber gloves are advisable as well.

Leprosy

This is a disfiguring disease due to infection of the skin, mucous membranes and nerves by a bacillus known as the *Bacillus lepræ* or the leprosy bacillus.

In spite of the fact that leprosy has been known for centuries we are still deplorably ignorant about it. We do not know what is the incubation period nor the way in which it spreads. The bacillus has never been cultivated outside the human body though most other bacteria have been studied in this way

The disease is practically world wide. It has disappeared from a number of countries where once it was common, e.g Great Britain, France and Germany It is appallingly common in West Africa, certain parts of India, and in China. It occurs in Japan, Siberia, Australia and Central and South America.

The disease is not easily communicable. It has been shown that cohabitation with a leper is by far the commonest feature of the history of cases. Physicians and persons in charge of lepers seldom become infected.

The disease takes three forms a nodular form, a nerve form, and a form in which both nodular and nerve lesions are present. In the nodular form lumps appear under the skin, especially on the face and ears, and, by smoothing out the normal folds of the skin, give such patients the lion face which serves to identify them at once.

When leprosy attacks the nerves the muscles of the affected part waste, and produce deformities such as the clawlike hands and deformed feet. Painless ulcers develop in the affected parts and fingers and toes may be lost. Blindness is common.

The onset of the disease is very gradual. Most cases come to light only after they have been active for months or years.

Prevention.

(*a*) Isolation of the patient. This should be done in an institution if he is infectious. During the stages of his disease in which he is not infectious he may be allowed to remain in isolation at home if arrangements can be made to the satisfaction of the Sanitary Authority A register of patients isolated at home should

be kept and it should be one of the conditions of their being allowed home isolation that they will notify any change of address to the Sanitary Authority They should be brought periodically for medical examination.

(b) Careful medical examination of all members of the leper's household for the detection of early cases. The vigorous treatment of all cases so found.

When a leper is isolated at home it is preferable that he should inhabit a separate hut in the yard rather than a room in the house. He should have his own latrine and his own crockery plate and glassware. These articles should not leave his premises. There is no objection to his food being cooked along with that of the rest of the household so long as the crockery used by him is not given the chance to become mixed with the rest. His clothing should be boiled by him before being sent to be washed and he should do as much for himself as possible. When a leper is so disabled as to be unable to look after himself it is best for all concerned to have him admitted to an institution.

Since children and young adults are more susceptible to the disease than older persons only elderly persons should be allowed to visit lepers.

CHAPTER VI

ELEMENTARY ENTOMOLOGY

THERE is a large group of animals of different shape, size and habits which, nevertheless, have a number of features in common. Their bodies are segmented. That is to say they are composed of a series of similar parts or segments all made to the same fundamental design. Each segment consists of a ring of tissue enclosing a cavity and carrying a pair of jointed organs known as appendages which may be used by the animal as jaws, legs, paddles or organs of sensation. The segments are covered with a skin or cuticle which is rigid and is known as the exoskeleton. Between the segments the skin is pliant to allow freedom of movement. Animals which possess a segmented body an exoskeleton and jointed appendages, are grouped in the Phylum *Arthropoda*.

In all arthropoda (from Greek—*arthron*, a joint, and *pous*, *podos* a foot) except a few degraded parasites in which all traces of segmentation are lost, the front segments are fused to form the head and their appendages are modified for dealing with food, or for sensory purposes. Behind the head the segments and appendages may be all alike or nearly so as for instance, in centipedes or the segments may be fused together and their appendages modified in various ways or altogether suppressed as in a crab or a scorpion.

Arthropods have a circulatory system which may be fairly elaborate and consist of heart, arteries, veins and capillaries or it may merely consist of a simple form of heart and one or two blood vessels, the blood circulating for the most part freely in the cavity of the body The blood is usually colourless.

All arthropods have the head appendages modified to form jaws.

The arthropoda are divided into five great classes (1) the *Onychophora*, slug like creatures (2) the *Crustacea* which have two pairs of antennae and at least five pairs of legs (lobsters, shrimps, crabs, etc.) (3) the *Arachnida* which are for the most part land arthropods. The majority of them breathe air The

grouping of the segments of the body is not constant but commonly two regions—the cephalo thorax and the abdomen can be recognised. The appendages never exceed six pairs, of which four pairs are legs. There are no antennae (scorpions, king crabs spiders, mites, ticks, etc. (Fig 13)) (4) the *Myriapoda* which are distinguished by a single pair of antennae and the absence of any differentiation of the body into thorax and abdomen. Each segment usually carries appendages. They are land arthropods (centipedes and millipedes) (5) the *Insecta* have the body divided into head, thorax and abdomen. There is only one pair of antennae. The thorax carries three pairs of legs and usually one or two pairs of wings. The abdomen is segmented and does not carry legs.

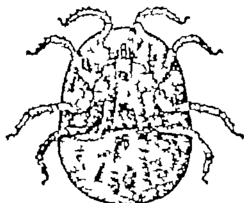


FIG. 13 —An Arachnid *Ornithodorus moubata*. (Castellani and Chalmers)

GENERAL DESCRIPTION OF AN INSECT

The typical insect has the body divided into three regions which are generally easily recognised. In front is the head which consists of six segments fused together Corresponding to these six segments are the appendages, *consisting of one pair of antennae*, and three pairs known respectively as the mandibles, maxillae and labrum which together form the mouth parts of the insect.

The thorax consists of three segments each of which bears a pair of legs, while the second and third segments carry each a pair of wings. The wings are membranous structures stiffened by a system of ribs or veins.

The abdomen consists of eleven segments.

The Head

The head of an insect is a chitinous structure
muscles, the brain and the pharynx.

At the sides of the head are the eyes. On the un
is the mouth. The part of the head lying above the
extending across the face is the *clypeus*

Projecting from the front edge of the clypeus is t
or upper lip In many insects that prick or suck th
is lengthened to produce a long organ known as the *epiph*

In the floor of the mouth there is a small projection o
the mouths of the salivary ducts open. When this proj
soft it is known as the tongue, but when it is so big as to
far beyond the mouth it is called the *hypopharynx*.
structures, together with the eyes, are known as the *app*
of the head.

The true appendages of the head are the antenn
three pairs of jaws.

The antennæ are generally placed between the eyes.
are usually flexible and segmented, but their form varies gr
in detail. They are organs of touch and smell.

The three pairs of mouth appendages are known as the j
They consist of a pair of mandibles a pair of first maxillæ an
pair of second maxillæ. The jaws vary a great deal. The maxi
bear jointed organs known as palps. The mandibles never ha
palps. In some insects the second maxillæ may be used part
or wholly behind the mouth to form the lower lip or *labium*, o
they may be modified so as to form a sheath for the other mouth
parts.

In some insects which do not feed as adults the mouth append
ages may be rudimentary or absent altogether

The Thorax

The thorax is the locomotor region of the body It is traversed
by the œsophagus and contains also the salivary glands. There
are also nerve cords, and the heart. But the main contents of
the thorax are the powerful muscles which m
wings. As we have seen, it is formed by and
segments, the appendages of which are to ree
pairs of jointed l
They are The wings are not app
stiffened an the skin. They are
by a framework of are

veins are tubes of chitin containing air The wings occur on the second and third thoracic segments. Their number is variable there are some insects without wings at all and there is a large and important group known as the *Diptera* in which only the front pair are present, the hind pair being reduced to two little club-shaped structures (*halteres*).

The Abdomen

The abdomen generally shows its segmented structure. It contains the stomach and intestine, and reproductive organs nerve cords, excretory organs and the abdominal tracheæ. There are no appendages to the abdominal segments.

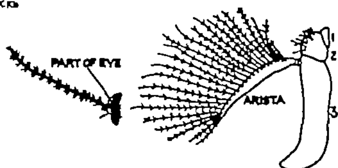
The Diptera

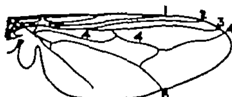
The foregoing description gives an account of the structure and organisation of any insect. But amongst the thousands of animals to which this description applies there are those which have certain peculiarities in common, either as regards the absence of fundamental characters in the adults, or in their method of development, or in other ways. The object of classification is to simplify the study of such animals by grouping them according to their common characters. There is a very important group of insects in which are collected all members having only one pair of wings and their mouth parts adapted for sucking and sometimes for piercing. This group is known as the Diptera.

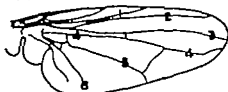
The diptera, or flies, are insects that possess only the front pair of wings, which are membranous, and have the mouth parts adapted for sucking and sometimes for piercing The hind pair of wings is reduced to a pair of club-shaped structures, the *halteres*. The metamorphosis is complete the larva being entirely different from the adult insect.

Within the group of diptera there are smaller groups in which the individuals are assembled again on account of some pecu liarity common to them all. One organ whose variation is used as a basis of classification is the antenna. In the diptera all members have jointed antennæ. But there are some in which the antennæ are long and are composed of a number of similar segments united by small joints, while others have antennæ composed of small numbers of dissimilar segments. Between those two extremes there are stages of gradation. For our purposes we need describe only the following two series

(1) *Nematocera* (*nema*, a hair *keras* a horn or antenna), in which the antennæ are long filaments composed of numerous similar segments. The average number is fourteen to sixteen







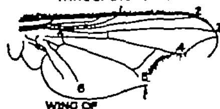


FIG. 15 —Illustrating types

never ... six. They are m... like

(2 ... (C ... a

ante... are not, or ... l"

antennæ are of diverse form usually they consist of three dissimilar segments

The Nematocera

The Nematocera are midge like flies, having slender antennæ and maxillary palps, both antennæ and maxillary palps being of considerable length.

An important family of the nematocera is the *Culicidæ* or mosquitoes.

The Family Culicidæ

The culicidæ can be distinguished from all other midge like flies by the venation of the wings (Fig 14) and by the fringe of scales running all along the hinder edge of the wings. They also have usually a long projecting proboscis. The head is small and pear-shaped. Much of its surface is taken up by the two eyes.

The antennæ, which are long and slender are composed of fourteen to sixteen segments. The first segment is more or less hemispherical and lies on the head the others are cylindrical. They bear whorls of hairs, sparse in the female shaggy in the male.

The proboscis is long and slender and is covered with scales. It encloses the other mouth parts. At the side of the proboscis are the maxillary palps which are also covered with scales and are jointed. They vary in length according to the sex or species of mosquito

The thorax is covered with scales or hairs. The wings are long and narrow and have the venation shown in Fig. 14 Their posterior edge is fringed with scales (not shown in figure) The legs are long and slender

The abdomen is long and narrow It consists of nine segments and its surface is either scaly or hairy

The eggs of the culicidæ are laid on the surface of water either in a sheet of jelly (corethra) or in groups or rafts (culex) or singly (anopheles). The individual egg is oval with one end blunter than the other It has a pigmented chitinous shell. A very fine external membrane either adheres closely to the shell or fits it more or less loosely so as to leave a space or float on either side of the egg.

The larvæ show considerable differences in detail. But mosquito larvæ all answer to the following general description

They are specially adapted for an aquatic life and they are unable to live out of water though they may exist for a considerable time in moist mud. They may be found in collections of water of any kind whether small or large, natural or artificial, temporary or permanent. They prefer fresh water but in desert regions and on the sea coast they may be found in distinctly brackish water

The three regions of the body of a culicid larva are all distinct.

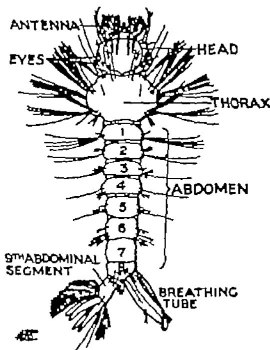


Fig 16 —A culicine larva (McGregor Mosquito Surveys.)

The head is globular There are two pigmented eyes. The antennæ are prominent. The mouth parts vary according to the food of the larva.

The thorax consists of three fused segments.

The abdomen consists of nine distinct segments. On the dorsum of the eighth segment the breathing organs open, either by two independent openings in a kind of trough or at the end of a chitinous breathing tube of varying length. The ninth segment carries the anus, and four tapering tracheal gills.

The larva moves through the water by vigorous wriggling

movements. It can remain submerged only for a limited time It must come periodically to the surface for air When larvæ are on the surface their attitude is governed by the length of the breathing-tube. If the breathing tube is long the tip lies at the surface of the water while the larva hangs head downwards at an angle to the surface. When the breathing-tube is short the larva looks as if it were plastered on the surface, the whole of the body lying horizontally Their attitude at rest affords a good rapid guide to the differentiation of culex from anopheline larvæ. The

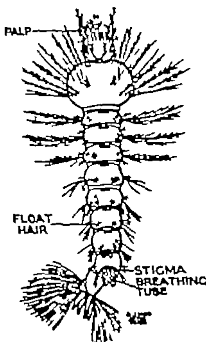


FIG. 17—An anopheline larva. Note the very short breathing-tube (compare with previous figure)
(*McGregor: Mosquito Surveys*)

culicine larva has a long breathing tube and therefore lies at an angle, the *anopheline larva, having a very short breathing-tube,* lies horizontally

The larva feeds continually and moults occasionally It grows rapidly in warm weather and may become fully grown in about eight days. Cold may retard its growth very much.

In the course of time the larva changes into the *pupa*, which has quite a different appearance from the larva. The head and

thorax become fused into one mass (cephalo-thorax) bearing two trumpet like breathing-tubes on its shoulders. The abdomen is curved under the cephalo-thorax not unlike that of a very small lobster If the pupal skin happens to be transparent one can see the eye of the adult insect, the legs and the developing wings. The pupa does not feed, so that the duration of the pupal stage is short, only a day or two in hot weather

When the adult is about to emerge the pupa straightens out and the cephalo-thorax splits along the back. The head of the adult insect appears through the slit, followed by the thorax, proboscis, legs and wings and, finally the abdomen. The

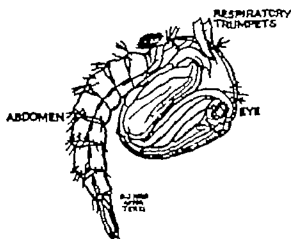


FIG. 18.—A mosquito pupa.
(*McGregor Mosquito Surveys*)

mosquito floats for a few minutes on the old pupal skin until its wings are hardened and fit for flight.

The family culicinæ is divided into two tribes the Anophelini and the Culicini. The tribal characters are shown below

ANOPHELINI	CULICINI
Adults	
Palps of both sexes as long as the proboscis. Thorax elongate and cylindrical.	Palps of females shorter than the proboscis. Palps of males usually as long as or much longer than proboscis. Thorax rounded.
Posterior (free) edge of the scutellum evenly rounded.	Posterior (free) edge of the scutellum trilobate, the central lobe always distinct.
Abdomen not densely invested with flat overlapping scales.	Abdomen densely invested with flat overlapping scales.

ANOPHELINI	CULICINI
Larvæ	
Larvæ without breathing-tube. Palmate hairs usually present on the dorsal surface of the abdominal segments three to seven.	Larvæ with distinct breathing-tube. No palmate hairs on the dorsal surface of the abdominal segments.
Bodies of larvæ when at rest or feeding lie parallel to and in contact with, the surface of the water	Bodies of larvæ when at rest at the surface of the water hang at an angle below the surface film.

The Brachycera

In the brachycerous flies the antennæ usually consist of three dissimilar segments of which the third is often larger than the first or second and is sometimes composed of several more or less distinct but rigid sub-segments. The third segment may moreover carry a stout bristle known as an arista which may be feathered, i.e. clad with small separate hairs (Fig 15). Of the Brachycera the most important family is that of the *Muscidæ*

The *Muscidæ* may be grouped according to whether the adults do or do not suck blood. Of the non blood-sucking muscidæ the important Genus is the genus *Musca*.

The species of genus *Musca* are all about the size of the common house fly The arista on the third antennal segment is feathered dorsally and ventrally The proboscis is soft and it can be drawn back into the mouth, i.e. it is *retractile*. It ends in large fleshy labella.

Musca domestica, the common house fly is found in all parts of the world. The head is dark, having a velvet black stripe on the brow (*Frons*). The back of the thorax (*Scutum*) is dusted with grey and indistinctly marked with four equi-distant black stripes of equal breadth. The abdomen is yellow with a median dark stripe and a dark tip In the males the eyes are set together in the female they are wide apart. The wing is illustrated in Fig 15

The eggs of this fly are white, sticky and shiny They are laid by the female in batches of 120-150 in organic rubbish which is fairly moist. The favourite material is stable sweepings, but domestic refuse, or any kind of organic refuse may be used.

The eggs may hatch in warm weather within twenty four hours. The larva is a small segmented maggot, blunt at the posterior end and tapering to the head. The head is just visible

D D T and Gammexane are extremely poisonous to insects either on contact or after having been eaten. They are poisonous to larvæ as well as to adults. They can be incorporated or dissolved in inert substances which are easily procurable. After solutions of them have been applied to surfaces a fine deposit remains which, during several weeks following the application, is deadly to insects resting upon it. They are both extremely deadly to mosquito larvæ in concentrations which are harmless to fish or domestic animals. This formidable combination of qualities has made them powerful weapons in the control of insect borne diseases.

D D T and Gammexane are commonly used as follows

1 As *sprays* dissolved in kerosene D D T as a 5 per cent. W/V solution, Gammexane as a 0 5 per cent. W/V solution. These solutions may be used as mosquito larvicides, or for the production of a deadly deposit on surfaces that is known as their residual effect. As the solubility of D.D T in kerosene is about 8 grmme. in 100 mils. and that of Gammexane 3·29 grmme. per 100 ml. the required solutions can readily be made.

2. As *dusts* containing 5 per cent. D D T or 0·5 per cent. Gammexane in an inert diluent such as china clay gypsum, fuller's earth, talc or even road dust. For the preparation of dusts it is best to purchase from the manufacturers specially prepared dust concentrates and dilute them locally since special apparatus is required to make a suitable powder of D.D T and Gammexane.

These preparations may be used as follows

1 *Mosquitoes* (a) *Larvæ*. Spray or dust applied to the surface of the water in which the larvæ are present. (b) *Adults* Spraying of walls and ceilings of rooms, all surfaces of byres, sheds, trees and walls on which mosquitoes are known to rest.

2. *Rat and other Fleas*. As dusts insufflated into rat holes and laid along rat runs.

3 *Lice* D.D T 10 per cent. in Talc dusted upon the clothes and into the hair

4 *Bugs* Bedsteads, furniture, walls, ceilings and floors sprayed with solutions of D.D T or Gammexane at the rate of about ½ gallon solution per 1 000 square feet of surface, and allowed to dry off so as to leave a deposit of D.D T or Gammexane on the surface

5 *Houseflies. Indoors* Spraying of walls, ceilings and other

surfaces with solutions of D.D T and Gammexane for their residual effect. If flies swarm into an apartment and it is desired to deal with them at once, the operation with a handspray of D D T or Gammexane solution containing 0·05 per cent. pyrethrins is recommended. The action of D D T and Gammexane on insects takes some time to become manifest so that if an immediate knock-out effect is desired the pyrethrins should be added to the insecticidal mixture.

Outdoors. Refuse Tips may be periodically dusted with 0·6 per cent. Gammexane in road dust or other suitable material.

NOTE. There are certain races of house fly which are not nearly so susceptible to D D T as are others. In such cases Gammexane should be used as the insecticide.

aestivo-autumnal malaria, may take twenty four to forty-eight hours to produce a number of daughter parasites varying between eight and twenty four or even more.

It is easily seen how the patient's blood may become greatly impoverished after a few weeks. If at the end of forty-eight hours each parasite originally introduced becomes, say eighteen, and each of the eighteen attacks a red blood cell, and forty-eight hours later gives rise to eighteen more it does not take long for there to be an enormous number of parasites in the circulation feeding on the red blood cells. It is this which causes the great and progressive anaemia in untreated patients. The kind of reproduction just described goes on for a certain time. After a time, however new forms of parasite, which are now known to be male and female forms, begin to appear So long as these circulate in the blood they show no reproductive activity but if they happen to be ingested by a female anopheline mosquito suitable for their propagation, fertilisation of the female parasite takes place in the stomach of the mosquito The fertilised female then pierces the wall of the stomach and comes to rest on the outside of the organ. There it increases in size and gives rise to a large number of very minute daughter parasites which eventually find their way through the body-cavity into the salivary glands which are lying close to the stomach. From the salivary glands they reach the hypopharynx by the salivary ducts, and when the mosquito next feeds on man they are injected into his blood-stream and multiply as has already been described.

The time required to render a mosquito infectious varies with the temperature, and to a certain extent with the parasite. The outside limits for natural tropical temperatures are from ten to eighteen days.

In the absence of re infection the malarial infection of the mosquito in the tropics does not last very long, a few weeks at most. In temperate regions where mosquitoes hibernate during the winter it is thought that the infection may remain dormant during hibernation, to become active again when the warmer weather causes the mosquito to resume an active life.

Liability to Epidemic Spread.—In malarious regions malaria is apt to appear in epidemic form. The reason for this is un known.

The prevention of malaria is directed in two main directions (*a*) the treatment of patients and carriers and (*b*) the control of

mosquito-breeding, by which is meant anopheline-breeding, in the locality

The treatment of patients and carriers devolves on the Medical Staff Here will be mentioned only the practice of what is known as drug prophylaxis.

Drug prophylaxis

Drug prophylaxis is the term used to denote the practice of the regular administration of anti malarial drugs with the object of preventing attacks of malaria from occurring in persons who may become infected. It has its greatest value in keeping fit newcomers to an endemic area who may be presumed to have no immunity to infection by the local strains of plasmodia. The practice is not a true prophylaxis because infection by the plasmodia is not prevented. All that happens is that, in favourable circumstances the infection is checked and is not allowed to develop to such an extent as to incapacitate the infected person. In this reason the term suppression is better than prophylaxis. When the drug is discontinued an attack of malaria may occur unless active treatment is instituted on the discontinuance of the suppressive dose.

There is a certain amount of difference of opinion on dosage, and of timing. The following is to be regarded more as a good working guide than as a definite régime.

Quinine hydrochloride, 5 grains daily or 15 grains every other day

Atebrin, Mepacrin, 0 2 gmme. twice weekly

Paludrine, 0·1 gmme. twice weekly

The least satisfactory of these drugs is quinine Atebrin is better than quinine, and paludrine is the best in fact, some workers consider that in the dosage indicated paludrine may be a true causal prophylactic.

Suppressive drugs should be taken so long as the danger of malarial infection threatens, and for a fortnight to three weeks after leaving the endemic area.

Mosquito control will be discussed in another place.

Yellow Fever

Yellow fever is an acute disease characterised by fever jaundice, albuminuria and hæmorrhage from the stomach. It is due to a filtrable virus and is spread by mosquitoes of the genus *Ædes*.

The case mortality is about 30 per cent.

The incubation period is short, two to five days.

Liability to Epidemic Spread.—In a susceptible population living in contact with the mosquito-carrier *Ædes ægypti*, the introduction of a case of yellow fever may be followed by a brisk epidemic. The disease is endemic in tropical West Africa, the West Indies and tropical America.

The method of transmission is as follows

To become infected the mosquito must feed on a patient during *the first three days of his fever* The virus is apparently present in the blood only during the first three days. In the mosquito the virus must apparently undergo an incubation of about twelve days duration. Within this period the mosquito cannot transmit the disease. After twelve days, however the mosquito is infective and may infect healthy persons on whom it feeds. The infection remains in the mosquito during the rest of its life Like anopheles, only the females of the genus *Ædes* suck blood and they only are dangerous.

The prevention of the disease rests in the prompt recognition of cases and their isolation under a mosquito-net or in a mosquito-proof room. The control of mosquitoes of the genus *Ædes* is another important measure. It will be described in the general section on mosquito control.

Persons going to infected areas may now be immunised by being given a course of injections of weakened yellow fever virus.

Dengue

Dengue is an acute fever caused by a filtrable virus. The disease is transmitted by mosquitoes of the genus *Ædes* and it may occur in epidemic form. It is not a fatal disease, but an epidemic of it may cause great disorganisation in a region through prostrating the staffs of transport and distributing agencies, police and other organisations.

The incubation period is short as a rule three to six days.

Liability to Epidemic Spread.—The disease tends to occur in epidemics which are almost explosive in their violence. It is endemic all through the tropics and the sub-tropics.

The carrier state is not known to exist.

The only mosquito known to transmit dengue at the present time is *Ædes ægypti* (*Stegomyia fasciata*) and the preventive measures which can be taken are those applicable to the control of yellow fever

Filariasis

This term is used in the restricted sense of meaning infestation with the worm *Wuchereria* (formerly *Filaria*) *bancrofti* Infection with this worm produces a number of disease conditions in the body the most striking of which is the great increase in size of certain limbs or organs. This condition is known as *elephantiasis* and it is due to the obstruction of the circulation of lymph in the affected parts.

Wuchereria bancrofti is found practically throughout the tropics and sub-tropics. In endemic areas the remarkable feature about this infection is the large number of persons harbouring the worms who apparently suffer from no ill effects. There seems to be no relation between the number of infected persons and the number who show evidence of their infection.

If a drop of the blood from each of a number of persons living in a tropical area is taken at night between the hours of 8 p.m. and midnight and examined under the microscope it is almost certain that in some specimens there will be seen tiny eel like creatures swimming about in the plasma. They can generally be picked up by the disturbance they cause among the red blood corpuscles which occupy the field of view These creatures are the embryos of the parasitic round worm *Wuchereria bancrofti*, the adults of which live in the lymphatic vessels and glands of various parts of the body The parent worms are long thread-like creatures. The males measure about 40 mm. in length by about 1 mm. in thickness the females are almost twice as long as the males. The females in due course give birth to large numbers of living embryos which are microscopic in size and are known as *microfilariæ* The embryos are discharged into the lymph and they have the peculiarity that they only appear in the superficial blood in large numbers at night. The number of embryos found in the superficial blood increases greatly from about sunset to midnight after which time they begin to diminish. During the day they do not appear in the superficial blood in easily detectable numbers so that unless the people are examined at night many cases of the infection are apt to be overlooked.

The microfilariæ undergo no further development in man. In the absence of a suitable mosquito host they probably die though their numbers are constantly being maintained for years by the birth of new individuals from the parents. If however a suitable mosquito should suck blood containing the microfilariæ, they pierce

the stomach of the mosquito and penetrate between the fibres of the great muscles of the thorax. There they undergo development into larvæ. When the larvæ are fully grown they leave the thoracic muscles and make their way into the proboscis of the mosquito These larvæ are the infective stage of the parasite so far as man is concerned. When the infected female mosquito is feeding on man the larvæ crawl down the proboscis and pierce the skin. Having done so they make their way through the capillary circulation to the main blood-stream and eventually gain the lymphatics. In the lymphatic system they grow into adults and after the females have become fertilised the microfilariæ begin to appear in the blood. The patient is now infective to another mosquito

In certain regions of the world the microfilariæ swarm in the blood during the day and not at night. It has been noted that when this takes place the mosquito which transmits the infection feeds by day and not by night. What is known as the period icity of the filaria, by which term is meant the regularly recur ring time at which the microfilariæ swarm in the subcutaneous blood, seems to be regulated by the feeding habits of the mosquito. When the transmitting mosquito is a night feeder the filaria exhibits what is known as nocturnal periodicity when the mosquito is a day feeder the periodicity of the filaria is diurnal.

Carrier State.—From what has already been written it will be clear that the carrier state is very common in endemic areas. The results of surveys have shown that in endemic areas any proportion between 10 and 30 per cent. of the inhabitants are carriers.

Period of Infectivity of Patient or Carrier.—The patient or carrier is infective to mosquitoes so long as he shows microfilariæ in his peripheral blood. In the absence of suitable mosquitoes the patient or carrier is of no danger to the community

Prevention.—This is a bigger problem than it is regarding any of the diseases so far considered because mosquitoes of all three genera culex, anopheles or aedes, have been proved to be capable of acting as the intermediate hosts of the parasites in different regions.

Other parasitic filariæ are known to exist, some of which are transmitted by mosquitoes others by biting flies of other families. They are not so widespread as *Wuchereria bancrofti*

and though they may have considerable local importance it is only necessary to mention them here for the sake of completeness.

ANTI MOSQUITO MEASURES

Anti-mosquito measures can be satisfactorily evolved only after a thorough study has been made of the habits of the mosquitoes in the area in which the campaign is to be waged. The problem has first to be set, the various factors entering into it have to be studied, after which a decision has to be taken as to the particular factor on which the activities of the Public Health Department are to be concentrated.

In any anti mosquito campaign there are two parties participating the Public Health Department of the local authority and the general public. Each party has his appropriate share and unless each pulls his weight the campaign is unlikely to be successful. The weaker member is the general public because its resources are subdivided into a vast number of units represented by the inhabitants of the area, each of whom must carry out his allotted part of the campaign. This weakness in the team has been the principal reason why so much of the control work attempted in tropical areas has been ineffective. It has, so far been found impossible to induce the general public individually to take such measures as lie within their power simultaneously and for a long enough period to ensure success.

In spite of the fact that the measures to be selected for the control of mosquitoes vary so greatly in different situations our choice is limited to a fairly restricted number These will now be mentioned. They are tools, as it were, of the campaign, and they do not vary Where the difficulty comes in is in making the decision regarding the measure to be employed and the way in which it is to be applied.

We have already learnt that during their lifetime all mosquitoes of whatever kind spend part of their life in water and part on land. The mosquito can therefore be attacked either in its larval and pupal stages during which it lives in water or in its adult stage during which its life is on land. It is clearly more vulnerable in the larval and pupal stages in which its distribution is limited by the extent of the water in which it lives, than in its adult stage in which it has the power of flight, and can move freely over large areas. The anti mosquito campaign is there

fore largely occupied with the larval and pupal stages of the mosquito though measures are also devised for the protection of the population from adult mosquitoes.

In all that follows the *object of the anti mosquito campaign* should not be overlooked. It is to prevent the spread of a disease by mosquitoes. The campaign must therefore be designed with reference to the disease under consideration and the methods selected must be adapted so as to bear most strongly on the kind of mosquito concerned in its transmission.

Methods of Protecting the Population against Adult Mosquitoes

It is clear that if adult mosquitoes are prevented from feeding upon human beings they will not become infected with any of the diseases we have been considering One way of doing this is to provide the mosquitoes with an abundant supply of food *more acceptable to them than human blood. In some parts of* the world it has been found that the stabling of domestic animals in certain areas has diverted the mosquito traffic from the human habitations to the stables because apparently when offered a choice, the mosquitoes concerned preferred the blood of domestic animals.

Another way is to screen the population from mosquitoes by inducing the people to live in mosquito-proof houses or rooms, or at least to sleep under a mosquito-net.

The screening of houses and even of rooms is a measure which is entirely out of reach of the majority of the people. The effective screening of a building is costly to carry out and sufficiently expensive to maintain to make it completely prohibitive as a general measure. It is useful, and may be essential, for Europeans who can afford the initial cost and the subsequent maintenance charges. But at least it is only a passive means of defence and it does not cause any radical improvement in the situation.

If screening is decided upon it is better to design the house as a screened house [illegible] than to try to screen a house already built [illegible] *effective th*[illegible] should be incorporated in t[illegible] the way [illegible] house is used may compl[illegible] effects of [illegible] For [illegible] if [illegible] de [illegible] in their [illegible] y is [illegible] lef

open. It is therefore best to erect the house inside a screened framework so that only the exterior is screened and internal com municating doors and windows do not require it.

The screening is effected by the use of metal gauze having at least 18 strands to the linear inch. The metal should be non corrosive and the most durable is phosphor bronze or brass.

The best type of design is a verandah type, i e. a dwelling surrounded on all sides by a well ventilated verandah 6 to 8 feet in breadth. All openings on this verandah are carefully fitted on the outside with the metal screening and all doors giving access to the premises are doubled, screened, and separated by a short, mosquito-proofed passage. These doors should open outwards so that mosquitoes resting on their outer surfaces will tend to fly away from the house rather than into it when the door is opened (the same holds good for fly-screening) and they should be constructed in such a way that they automatically shut, either by gravity or by means of a spring The verandah windows and other ventilating devices should open inwards.

If the house is double-storied the upper rooms may have only the windows screened unless there is a verandah with doors leading to it, in which case it is preferable to screen the whole verandah in the same way as is done on the ground floor

The object of screening is to prevent the access of mosquitoes to the house. Therefore the building should be of sound work manship and there should not be any unscreened openings through which mosquitoes could enter

The screening should be scrupulously inspected by the occupant at regular intervals and the servants should be instructed to report at once any defective screening which may come to their notice. The wire is very fine and if it receives a blow the strands may become distorted and make openings big enough to allow mosquitoes to enter Mosquitoes are remarkably per sistent in their search for holes in the screening

Climbing plants should not be permitted to grow up the screening or its supports.

If the whole house cannot be screened, the living and dining-rooms should be mosquito-proofed, and these rooms used during the time the mosquitoes are active. They should be fitted with self-closing doors opening outwards.

Bed Nets.—The use of bed nets by the population would do much to reduce the amount of mosquito-borne disease in the

tropics. Here again we stumble against the economic disability. Bed nets cost money. Moreover they need a certain degree of intelligent use if they are to be effective.

The nets are usually made of cotton, but in some countries suitable material made from locally prepared fibre is obtainable. The weave should be regular and there should be not less than 16-18 *meshes to the linear inch. The net should be big* enough to enclose the bed and leave a space of several feet above the sleeper. When not in use it should be tied up.

The net is supported either by a wooden or wire frame suspended from the roof of the room, or by a rectangular frame fitted to the bed. The net should be attached to the inside of the frame so that it may be well tucked in all round the mattress when it is in use. It *should not be allowed to hang over the frame* with its end resting on the floor. In this position it becomes a mosquito-trap. The free edge of the net should be hemmed with a strip of cotton or other material at least a foot or 18 inches wide. This strengthens the net, and also prevents a mosquito biting any part of the body which may come into contact with the net during sleep. It is advisable for this reason to use broad beds rather than narrow ones.

Suitable Clothing.—The wearing of low-cut dresses by women *in mosquito-infested areas is to be deprecated. Mosquito-boots* should be worn by both sexes in the evening.

Trapping of Adult Mosquitoes.—If mosquitoes are numerous, a certain number are bound to get into even screened houses and apartments. Hand-catching should therefore be done regularly. Since mosquitoes prefer shade they are to be looked for in shady corners, or on dark clothing hanging in wardrobes or against walls.

Special traps in the form of open boxes with black-painted interiors placed near collections of water which have been *denuded of shade are sometimes* used, not so much with the idea of reducing the number of mosquitoes as of obtaining specimens of the local species. The boxes *are left open* while in place and are closed and collected for examination when the sun is high.

Fumigation.—Fumigation may be used for the destruction of adult mosquitoes in houses, stables and byres. Any of the routine fumigants in sufficient concentration will serve for this. After fumigation the dead and stupefied insects are swept up and burnt.

Spraying.—When the spraying of the interior of habitations with an insecticidal solution was first done in South Africa and later in India, the intention was to kill mosquitoes sheltering there at the time of spraying. In South Africa a proprietory solution of pyrethrins known as Pyagra was used in the proportion of 1 part of pyagra to 17 parts kerosene oil. A twice weekly spraying was sufficient to reduce mosquitoes after a time to harmless numbers and to lessen the amount of malaria among the people living in the treated huts.

The new insecticides D.D.T. and Gammexane are not used in quite the same way but for their residual effect. These sprays are applied to all surfaces so as to leave a residue of the insecticidal substance wherever a mosquito may alight. The length of time such residues may remain effective depends upon the strength of the solution, the temperature of the apartment, whether the surface is part of an enclosure or is exposed to the weather and the nature of the surface, i. e. whether it is absorbent or non absorbent, rough or smooth. As a general rule one would be pretty safe in reckoning that indoor surfaces would remain deadly for about four weeks. We want to have some such figure in mind because spraying would have to be repeated throughout the mosquito season at that interval of time, and this governs the number of sprayers who will be needed. Further experience may shew that spraying is effective for a longer time, but this can only be found out on the spot.

If possible, the spraying should be done with a power sprayer fitted with an adjustable nozzle, but the ordinary flit gun is quite effective, if slower. Enough of the spray should be applied to the surface to make it visibly damp but not so much as to make the solution run or collect into drops.

Stables, outhouses and all shady places in the neighbourhood of dwellings should also be sprayed as these may be the principal resting places of the local mosquitoes.

In addition to the formulæ given on p. 90 the following are effective as *direct* sprays (little or no residual effect).

1. *Giemsa*.

Pyrethrum tincture	480 grammes
Odourless potash soap	180
Glycerin	240

(Pyrethrum tincture is prepared by adding 20 parts powdered

tropics. Here again we stumble against the economic disability Bed nets cost money Moreover they need a certain degree of intelligent use if they are to be effective.

The nets are usually made of cotton, but in some countries suitable material made from locally prepared fibre is obtainable. The weave should be regular and there should be not less than 16-18 meshes to the linear inch The net should be big enough to enclose the bed and leave a space of several feet above the sleeper When not in use it should be tied up

The net is supported either by a wooden or wire frame suspended from the roof of the room, or by a rectangular frame fitted to the bed. The net should be attached to the inside of the frame so that it may be well tucked in all round the mattress when it is in use. It should not be allowed to hang over the frame with its end resting on the floor In this position it becomes a mosquito-trap The free edge of the net should be hemmed with a strip of cotton or other material at least a foot or 18 inches wide. This strengthens the net, and also prevents a mosquito biting any part of the body which may come into contact with the net during sleep. It is advisable for this reason to use broad beds rather than narrow ones.

Suitable Clothing.—The wearing of low-cut dresses by women in mosquito-infested areas is to be deprecated. Mosquito-boots should be worn by both sexes in the evening

Trapping of Adult Mosquitoes.—If mosquitoes are numerous, a certain number are bound to get into even screened houses and apartments. Hand-catching should therefore be done regularly Since mosquitoes prefer shade they are to be looked for in shady corners, or on dark clothing hanging in wardrobes or against walls.

Special traps in the form of open boxes with black painted interiors placed near collections of water which have been denuded of shade are sometimes used not so much with the idea of reducing the number of mosquitoes as of obtaining specimens of the local species. The boxes are left open while in place and are closed and collected for examination when the sun is high.

Fumigation.—Fumigation may be used for the destruction of adult mosquitoes in houses, stables and byres. Any of the routine fumigants in sufficient concentration will serve for this. After fumigation the dead and stupefied insects are swept up and burnt.

Spraying—When the spraying of the interior of habitations with an insecticidal solution was first done in South Africa and, later in India the intention was to kill mosquitoes sheltering there at the time of spraying In South Africa a proprietory solution of pyrethrins known as Pyagra was used in the proportion of 1 part of pyagra to 17 parts kerosene oil. A twice weekly spraying was sufficient to reduce mosquitoes after a time to harmless numbers and to lessen the amount of malaria among the people living in the treated huts.

The new insecticides D D T and Gammexane are not used in quite the same way but for their residual effect. These sprays are applied to all surfaces so as to leave a residue of the insecticidal substance wherever a mosquito may alight. The length of time such residues may remain effective depends upon the strength of the solution, the temperature of the apartment, whether the surface is part of an enclosure or is exposed to the weather and the nature of the surface i e. whether it is absorbent or non absorbent, rough or smooth. As a general rule one would be pretty safe in reckoning that indoor surfaces would remain deadly for about four weeks. We want to have some such figure in mind because spraying would have to be repeated throughout the mosquito season at that interval of time, and this governs the number of sprayers who will be needed. Further experience may shew that spraying is effective for a longer time, but this can only be found out on the spot.

If possible, the spraying should be done with a power sprayer fitted with an adjustable nozzle but the ordinary flit gun is quite effective, if slower Enough of the spray should be applied to the surface to make it visibly damp but not so much as to make the solution run or collect into drops.

Stables, outhouses and all shady places in the neighbourhood of dwellings should also be sprayed as these may be the principal resting places of the local mosquitoes.

In addition to the formulae given on p 90, the following are effective as *direct* sprays (little or no residual effect)

1 *Glemsa.*

Pyrethrum tincture	480 grammes
Odourless potash soap	180
Glycerin	240

(Pyrethrum tincture is prepared by adding 20 parts pondered

pyrethrum blossoms to 100 parts of alcohol. Allow to macerate twenty four hours and filter) Use above spray diluted with 20 times its own weight of water just before use.

2. Water white kerosene — 1 gallon
Pyrethrum powder — ½ lb
Methyl salicylate — 3 fl. oz.

Mix and stir frequently during two hours filter Use undiluted

3 *Holt.*

60 grammes fresh pyrethrum powder are placed in a bottle with 120 c.c. commercial chloroform. Stopper well and shake vigorously at intervals for a period of two hours. Filter To the filtered extract add enough kerosene oil (water white) to make one litre of solution. Spray freely

N.B Pyrethrum powder should always be used *fresh* If it is stale it has no insecticidal value.

Measures directed against the Larvæ and Pupæ

Measures directed against the aquatic forms of the mosquito may be either temporary and palliative, or permanent. It is always advisable to substitute a temporary measure by a per manent one as soon as it can be done at a reasonable cost. A temporary measure is one which is directed against the insects only the permanent measure is applied to get rid permanently of the water serving as mosquito nurseries.

Temporary Measures.—Application of D.D T or Gammexane in solution. This has entirely superceded the application of oils or paris green. The strengths given on p. 90 are effective in amounts representing ten milligramme D.D T or 1 milligramme Gammexane per square yard of surface. The action of the solution can be greatly improved by adding to it a substance known as a spreading agent. 0·5 per cent. cresylic acid is suit able spreader another which has been recommended is 0 25 per cent. commercial resin. Small pools may be sprayed with these preparations with a flit gun or any of the sprayers formerly used for oiling Larger areas of water may be treated by spraying from a punt or boat and important marshes difficult of access may be sprayed from the air This very expensive method is spectacular but is of extremely limited usefulness and is, in any case, outside the scope of the Sanitary Inspector

When all due credit has been given to the modern insecticides

there remains the hard fact that the success of malaria control still depends upon scrupulously careful work on the ground. It is still necessary to have a ground organisation which will make certain that no breeding places are overlooked. The general type of organisation evolved for this purpose is the parcelling out of the area into the primary units of treatment. These will naturally vary in size according to the nature of the area as disclosed by a preliminary survey Each primary unit is laid down on a large scale map and given an identifying symbol. A number of these units is assembled into a larger unit and put in charge of a man whose duty it is to spray them regularly with insecticide and ensure that the aquatic stages of the mosquito cannot maintain themselves in them. A number of sprayers are grouped for supervisory purposes under a sectional foreman who is responsible for their regular attendance, for supervising their work and for furnishing them with the necessary supplies. He is also responsible for keeping the records of his area A number of the sectional foremen are made responsible to a more senior technical officer who is, in turn, responsible for his area to the officer in charge of the whole campaign. All the supervisory officers have inspection duties and it is a valuable measure to have, as well, Field Inspectors at the headquarters who can make surprise inspections of any part of the area in which the work is in progress.

The sprayers are detailed daily to the places which they have to spray They are required to mark their presence by a permanent or other easily distinguishable device when they are on the job This saves a great deal of the supervisors' time.

At the lowest level there is also the larva and imago checker working under the immediately superior administrative officer His job is to examine all collections of water in the area allocated to him and report whether or not they contain larvæ or imagos. New collections of water are recorded on the working maps. He is required to catch and send to his supervisor for further action the larvæ and imagos which he finds. With each specimen he encloses a note written by a graphite pencil (not indelible) stating the date on which the find is made and the breeding place in which the specimens were found.

D.D T and Gammexane can also be used as larvicides in the form of dusts, but they are not so convenient to handle as solutions.

There are certain precautions to be observed in the application of larvicides. The presence of surface weeds and grass in appreciable quantity interferes with the spreading of the solution so that they should be removed from the water before the spraying is done. If a breeze is blowing at the time the spraying should be done along the windward side of the water so that the film may be carried by wind action over to the leeward side and thus cover the whole surface.

Small slowly moving streams may be fitted with automatic oilers. These are generally drums of the larvicidal solution mounted on a stand straddling the stream. An automatic dripper is arranged by piercing the bottom of the container with a nail through a pad of cotton waste. The nail acts as a wick and the mixture slowly drips from it. The container should be fixed at such a height above the water level as to make the drop of mixture break up on impact with the surface.

Larvivorous Fish.—There are certain species of fish which feed on mosquito larvæ. These may be introduced into waters requiring control. Before introducing the fish it must be ascertained that the water is not already occupied by fish which may feed on the larvivorous species. The water should be kept clean of weeds and grass to make this measure effective. It is more effective in cisterns and small tanks than it is in natural marshes and streams.

Screens.—In towns and around rural habitations water tanks are frequently necessary. When the water supply is some distance away from rural homes it is the usual practice to store a certain quantity on the premises. Such tanks and containers frequently act as nurseries for the mosquitoes which frequent the premises. All unnecessary containers should be abolished. Those which must be kept should be very carefully screened so that the adult female mosquitoes cannot get to the water to lay their eggs in it. All such containers should be registered, especially in towns, and regularly inspected by the sanitary staff to make sure that they are being kept in repair and are being properly used. It is always better to have the inlet of the container permanently sealed by a screen and have the water withdrawn by means of a tap near the bottom.

Permanent Measures.—Permanent anti mosquito measures are directed to the abolition of all collections of water in which mosquitoes may breed.

Anti Mosquito measures in Towns

Malaria is not usually a disease of towns. The anopheline mosquito prefers the open spaces of the suburbs and the open country for its breeding places. Still, in some places, e.g Bombay anophelines must be counted among the so-called domestic mosquitoes. When they occur they are generally found to breed in wells. Their abolition rests in closing over the well head and drawing the water by means of a pump.

The culex and ædes groups are emphatically domestic mosquitoes, though they also occur in open country The characteristic about them is that their larvæ seem to be able to come to maturity in small collections of water varying in purity from almost pure rain-water to the intensely polluted contents of cess-pits and the drainage from cowsheds. They may be found not only outside the house but also inside, in such small collections of water as are used in ant-guards, in the plates underneath flower pots, in neglected flower vases and perhaps in other water containers in bedrooms only occasionally used. Where there are water-closets the pan or flushing tank of the apparatus in vacant houses is a fruitful source of mosquito nuisance.

Collections of miscellaneous rubbish in yards and between buildings may also provide breeding places old motor tyres used tins bottles, broken bamboos, rejected chamber-pots, old coco-nut husks, in fact, anything capable of holding water serves as a nursery

The establishment of a town-cleansing service will do much to eliminate these small nuisances. But it requires constant inspection on the part of the sanitary staff to ensure that all such rubbish is cleared out of the yards and properly disposed of. Even when there is an efficient town-cleansing service many tenants do not make full use of it so far as rubbish of the above-mentioned kind is concerned.

Another fruitful source of nuisance in towns is the stone tanks used to store water on the premises in places where there was formerly an intermittent supply Even when a constant water supply has been provided such tanks survive and it is sometimes difficult to get rid of them. Screening is generally of little use but stocking them with larvivorous fish may result in their being kept free of larvæ.

About the houses themselves we have to look for defective or blocked roof gutters. In gardens, holes in trees, ornamental ponds, or broken bamboos may have to be dealt with.

There are certain precautions to be observed in the application of larvicides. The presence of surface weeds and grass in appreciable quantity interferes with the spreading of the solution so that they should be removed from the water before the spraying is done. If a breeze is blowing at the time the spraying should be done along the windward side of the water so that the film may be carried by wind action over to the leeward side, and thus cover the whole surface.

Small slowly moving streams may be fitted with automatic oilers. These are generally drums of the larvicidal solution mounted on a stand straddling the stream. An automatic dripper is arranged by piercing the bottom of the container with a nail through a pad of cotton waste. The nail acts as a wick and the mixture slowly drips from it. The container should be fixed at such a height above the water level as to make the drop of mixture break up on impact with the surface.

Larvivorous Fish.—There are certain species of fish which feed on mosquito larvae. These may be introduced into waters requiring control. Before introducing the fish it must be ascertained that the water is not already occupied by fish which may feed on the larvivorous species. The water should be kept clean of weeds and grass to make this measure effective. It is more effective in cisterns and small tanks than it is in natural marshes and streams.

Screens.—In towns and around rural habitations water tanks are frequently necessary. When the water supply is some distance away from rural homes it is the usual practice to store a certain quantity on the premises. Such tanks and containers frequently act as nurseries for the mosquitoes which frequent the premises. All unnecessary containers should be abolished. Those which must be kept should be very carefully screened so that the adult female mosquitoes cannot get to the water to lay their eggs in it. All such containers should be registered, especially in towns, and regularly inspected by the sanitary staff to make sure that they are being kept in repair and are being properly used. It is always better to have the inlet of the container permanently sealed by a screen and have the water withdrawn by means of a tap near the bottom.

Permanent Measures.—Permanent anti-mosquito measures are directed to the abolition of all collections of water in which mosquitoes may breed.

Anti-Mosquito measures in Towns

Malaria is not usually a disease of towns. The [illegible] mosquito prefers the open spaces of the suburbs and the open country for its breeding places. Still, in some places [illegible] Bombay anophelines must be counted among the [illegible] domestic mosquitoes. When they occur they are [illegible] to breed in wells. Their abolition rests in closing over the [illegible] head and drawing the water by means of a pump.

The culex and aedes groups are emphatically domestic mosquitoes, though they also occur in open country. The characteristic about them is that their larvæ seem to be able to come to maturity in small collections of water varying in purity from almost pure rain water to the intensely polluted contents of [illegible] pits and the drainage from cowsheds. They may be found not only outside the house but also inside in such small collections of water as are used in ant-guards, in the plates under [illegible] flower-pots in neglected flower vases and perhaps in [illegible] water containers in bedrooms only occasionally used. Where there are water-closets the pan or flushing tank of the apparatus in vacant houses is a fruitful source of mosquito nuisance.

Collections of miscellaneous rubbish in yards and between buildings may also provide breeding places: old motor tyres, used tins, bottles, broken bamboos, rejected chamber pots, old coco-nut husks, in fact, anything capable of holding water serves as a nursery.

The establishment of a town-cleansing service will do much to eliminate these small nuisances. But it requires constant inspection on the part of the sanitary staff to ensure that all such rubbish is cleared out of the yards and properly disposed of. Even when there is an efficient town-cleansing service many tenants do not make full use of it so far as rubbish of the above-mentioned kind is concerned.

Another fruitful source of nuisance in towns is the stone tank used to store water on the premises in places where there was formerly an intermittent supply. Even when a constant water supply has been provided such tanks survive and it is sometimes difficult to get rid of them. Screening is generally of little use, but stocking them with larvivorous fish may result in their being kept free of larvæ.

About the houses themselves we have to look for defective or blocked roof gutters. In gardens holes in trees, ornamental ponds, or broken bamboos may have to be dealt with.

There are certain precautions to be observed in the application of larvicides. The presence of surface weeds and grass in appreciable quantity interferes with the spreading of the solution so that they should be removed from the water before the spraying is done. If a breeze is blowing at the time the spraying should be done along the windward side of the water so that the film may be carried by wind action over to the leeward side, and thus cover the whole surface.

Small slowly moving streams may be fitted with automatic oilers. These are generally drums of the larvicidal solution mounted on a stand straddling the stream. An automatic dripper is arranged by piercing the bottom of the container with a nail through a pad of cotton waste. The nail acts as a wick and the mixture slowly drips from it. The container should be fixed at such a height above the water level as to make the drop of mixture break up on impact with the surface.

Larvivorous Fish.—There are certain species of fish which feed on mosquito larvæ. These may be introduced into waters requiring control. Before introducing the fish it must be ascertained that the water is not already occupied by fish which may feed on the larvivorous species. The water should be kept clean of weeds and grass to make this measure effective. It is more effective in cisterns and small tanks than it is in natural marshes and streams.

Screens.—In towns and around rural habitations water tanks are frequently necessary When the water supply is some distance away from rural homes it is the usual practice to store a certain quantity on the premises. Such tanks and containers frequently act as nurseries for the mosquitoes which frequent the premises. *All unnecessary containers should be abolished.* Those which must be kept should be very carefully screened so that the adult female mosquitoes cannot get to the water to lay their eggs in it. All such containers should be registered, especially in towns, and regularly inspected by the sanitary staff to make sure that they are being kept in repair and are being properly used. It is always better to have the inlet of the container permanently sealed by a screen and have the water withdrawn by means of a tap near the bottom.

Permanent Measures.—Permanent anti mosquito measures are directed to the abolition of all collections of water in which mosquitoes may breed.

Anti Mosquito measures in Towns

Malaria is not usually a disease of towns. The anopheline mosquito prefers the open spaces of the suburbs and the open country for its breeding places. Still, in some places e g Bombay anophelines must be counted among the so-called domestic mosquitoes. When they occur they are generally found to breed in wells. Their abolition rests in closing over the well head and drawing the water by means of a pump

The culex and aedes groups are emphatically domestic mosquitoes, though they also occur in open country The characteristic about them is that their larvae seem to be able to come to maturity in small collections of water varying in purity from almost pure rain-water to the intensely polluted contents of cess pits and the drainage from cowsheds They may be found not only outside the house but also inside, in such small collections of water as are used in ant-guards, in the plates underneath flower-pots, in neglected flower vases and perhaps in other water containers in bedrooms only occasionally used. Where there are water-closets the pan or flushing tank of the apparatus in vacant houses is a fruitful source of mosquito nuisance

Collections of miscellaneous rubbish in yards and between buildings may also provide breeding places old motor tyres used tins bottles, broken bamboos, rejected chamber-pots, old coco-nut husks, in fact, anything capable of holding water serves as a nursery

The establishment of a town-cleansing service will do much to eliminate these small nuisances. But it requires constant inspection on the part of the sanitary staff to ensure that all such rubbish is cleared out of the yards and properly disposed of. Even when there is an efficient town-cleansing service many tenants do not make full use of it so far as rubbish of the above mentioned kind is concerned.

Another fruitful source of nuisance in towns is the stone tanks used to store water on the premises in places where there was formerly an intermittent supply Even when a constant water supply has been provided such tanks survive and it is sometimes difficult to get rid of them. Screening is generally of little use but stocking them with larvivorous fish may result in their being kept free of larvae.

About the houses themselves we have to look for defective or blocked roof gutters. In gardens, holes in trees, ornamental ponds, or broken bamboos may have to be dealt with

are moved on to it. The sick and infected are left in the old village which becomes a temporary hospital and quarantine station. Settlement in cleared areas should not be carried out with less than 500 persons. A smaller number cannot maintain the cleared area satisfactorily

The spraying of D.D.T. and Gammexane by aircraft over a belt is being tried at the present time. Aerial spraying may be reinforced by the use of Gammexane smoke generators operated at ground level. Special weather conditions are necessary to promote the diffusion of the smoke throughout the vegetation. The spraying and smoking are used for the residual effect of the insecticide and are clearly not a suitable method in areas exposed to frequent rain storms, which would wash the deposit off the vegetation. Promising results have been obtained in certain parts of Africa and it is possible that further experience of these and similar methods may result in great economies being made in tsetse fly control. Aerial spraying is however very expensive.

Chaga's Disease

This disease occurs in Brazil and in other parts of South America. It is caused by a trypanosome. The disease occurs most frequently among the poor and children are more often attacked than adults. The trypanosome causing the disease apparently occurs as a parasite of that strange animal the armadillo.

Man is infected by the bite of a particularly vicious bug named *Triatoma megista*. The bugs live in the burrows of armadillos, but they frequently infect dilapidated or badly constructed hovels.

The disease is difficult to control on account of the poverty and low standard of living among those exposed to the infection. No successful medical treatment for the disease has yet been discovered.

Destruction of bugs by fumigation where this is possible or by dusting with Gammexane dust the location of houses at a distance from the burrows of armadillos and the clearance of armadillos from the neighbourhood of villages are the only preventive measures which can be taken at present.

LEISHMANIASIS

Leishmaniasis is the name given to at least three apparently different diseases caused by a protozoon known as *Leishmania*.

It must be remembered that our knowledge of disease is very far from being complete and we do not know whether in fact the Leishmaniae found in Kala Azar are the same as those found in Oriental Sores or in the South American disease known as Espundia. It is possible that they are different species in which case the fact that they differ in their effects on man is understandable. But, so far we know of no means of proving this.

The only continent from which Leishmaniasis has not been recorded as being endemic is Australia It is endemic in Europe in countries bordering the Mediterranean in tropical and North Africa in tropical Asia and Northern China and in Central and South America.

Kala Azar

A chronic infectious disease caused by the protozoon parasite *Leishmania donovani* manifested by irregular fever wasting enlargement of the spleen and liver

Incubation Period.—Unknown. The reason for this is that the disease may not develop clinically for some time

Liability to Epidemic Spread.—This disease may spread epidemically but the rate of spread is much slower than that of most epidemic outbreaks. It may be very fatal, and cause widespread misery and disorganisation. It is endemic in Paraguay and the Argentine, in tropical Africa and the Mediterranean coasts of both Africa and Europe. In India the endemic areas are in the South and East and in China in the North.

Period of Infectivity of the Patient.—The patient may be regarded as infective all through his illness.

Carrier State.—Persons harbouring the infection in latent form may conceivably act as carriers. Dogs may act as carriers in the Mediterranean area.

Channels of Infection.—The channel of infection from the patient to the healthy is thought to be the Sand-fly

Prevention.—The main preventive measures undertaken in endemic areas are the provision of travelling clinics for the diagnosis and treatment of the disease. So far this has been the most effective means devised for its control. In Assam, where the disease has caused an appalling mortality the situation was so serious as to justify the enactment of legislation making it compulsory for infected persons to undergo a complete course of

curative treatment. Legislation of this kind is rare and the mere fact of its enactment shows how serious were the conditions with which the Government had to contend, especially when one remembers that a complete course of curative treatment might mean two injections of tartar emetic solution a week for three months.

Other measures can be applied during the time the treatment campaign is being organised. If the inhabitants of an infected household or village are removed and housed in new buildings at some distance from the infected place, new cases are rare. The old buildings are burnt. Rehousing of the people about a quarter of a mile from the former site is considered sufficient because sand flies do not travel far from their breeding-places in search of a blood feed. It is therefore unlikely that sand-flies will be found on the new site, whereas those occurring on the infected site will have been destroyed in the burning of the houses. This method is, however expensive and it does not prevent the extension of the disease into new areas. In fact, we know of no method which does this. Owing to the long incubation period of the disease it is possible for infected persons to proceed undetected to uninfected areas and in due course to start an out break there. Treatment does, however make the extension appreciably slower and it will limit a village outbreak if it is undertaken soon enough.

In areas where dogs are known to contract the disease all sick dogs should be rounded up and destroyed. Where possible a system of licensing dogs will help the local authority to obtain some revenue and will tend to reduce the number of dogs kept on premises.

Oriental Sore

This is an infection of the skin by Leishmania. The infection results in a slowly growing ulcer situated generally on the face or other exposed part of the body It is very common throughout the Middle East where it is severally known as Baghdad boil, Aleppo button or tropical sore. Delhi boil is the same thing occurring in Delhi. The infection is very disfiguring when it occurs on the face, as it leaves a large irregular scar Dogs may carry the infection in endemic countries.

The infection is thought to be spread by sand-flies.

Espundia

The South American form of Leishmania s is known as Espundia and in this disease ulcerations develop in the nose and pharynx. There may be gross destruction of the soft tissues and even bones.

As in other parts of the world, a sand fly is thou ht to be the transmitter

SAND FLIES

Sand-flies belong to the series of the diptera known as th *nemotocera*. They are very small two-winged flies, much smaller even than mosquitoes. The females live on blood

The family of sand flies is known as the *Psychodidæ* and the genus with which we are concerned is *Phlebotomus* The adults measure from 1½ to 2½ mm. in length. They are stumpy in form since they have a stout thorax and a comparatively short abdomen. They are densely covered with hairs and even the wings are hairy The *antennæ are a conspicuous feature of the* head of the insect. They have sixteen joints and are hairy

The life-history of sand-flies is briefly as follows The female lays her eggs singly in the dust of the building which she occupies. Sand-flies occupy damp shady cellars or cowsheds. In about a week a time a small maggot hatches from the egg It feeds on the organic matter present in the dust and grows by a succession of moults. The larval stage lasts about eight weeks in warm weather The pupal stage lasts about nine days The adult insects emerge from the pupal case during the night.

Sand flies are found in stables, cowsheds, old barrack rooms and in native houses. They do not seem to fly high, and are much more common on the ground floor of buildings than on the higher floors. The females subsist on human or ox blood. They are short lived creatures in nature. The males do not seem to feed at all so that their life is presumably short, while the females die after having laid their eggs There is therefore not the same danger of sandflies carrying infection over long periods as there is in the case of mosquitoes infected with malaria.

Anti-Sand fly Measures.—Strict domestic cleanliness and the abolition of domestic animals and fowls from the premises occupied by human beings are essential. Where means permit the establishment of sleeping-quarters on upper floors of houses

The control of bubonic plague centres largely around housing conditions and rodents. The patient is seldom a danger It is good practice, however to remove the patient to an infectious diseases hospital or ward.

Contacts should be inoculated against plague by means of a vaccine consisting of killed plague bacilli and they should be kept under surveillance for five days or a week. Those who develop plague should be removed to hospital.

On the occurrence of plague on premises the occupants should be evacuated. Bedding and clothing are collected, put into large canvas bags, and disinfected in a stream disinfector The floors

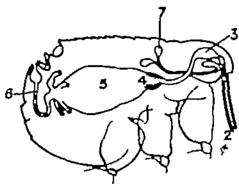


FIG 20 —Diagram of alimentary canal of flea.

1. Epipharynx.
2. *Hypopharynx.*
3. Pumping organ in pharynx.
4. Gizzard.
5. Stomach.
6. Rectum.
7. *Salivary glands.*

of the house are then swilled with a solution prepared by adding to 19 measures of water one measure of an emulsion of kerosene oil prepared by mixing kerosene oil 20 parts, water 5 parts and soft soap 1 part until an emulsion is formed. The soap should be dissolved in the warmed water and the kerosene oil poured slowly into the soap solution a little at a time, with constant churning, until the whole is emulsified. The dilute solution should not be used sparingly—the place should be swimming with it, because the object is to poison infected fleas and flea larvæ. The solution should be left in place for at least an hour It may then be mopped up

Another useful emulsion is

Cresol	5 parts
Soft soap	20
Hot water	75

The cresol and soft soap are added to the hot water with itinuous stirring For use make up a 5 per cent. solution in ter Use in the same way as the kerosene mixture.
Dusting rat holes and floors with D D T or Gammexane dusts d allowing the dust to lie for several days is also effective.
If the house is a wooden building raised off the ground by a indation wall, part of the flooring should be taken up so that cess may be had to the space underneath. Rat holes and runs are irched for and opened up more of the emulsion or dust being ed in each case to kill fleas which may happen to be there. hen all the holes are exposed they are then closed with the llowing mixture Cement 1 sand 3 broken glass 5 prepared cement concrete, see p 162. Double walls are opened up id if rat-runs are present they also are drenched with pulicide nulsion or dusted with D.D T or Gammexane dust. The above entioned measures should not take more than a working day but rangements must be made for the accommodation of the displaced tants for a night. They may be allowed to reoccupy the premises soon as the plague control staff have made them habitable again.
For buildings in which there is much rat infestation in the of or which, like certain grain stores, are clearly badly infested ith rats, fumigation with burning sulphur after the rat holes i the ground have been stopped up is as effective a measure of t destruction as any The strength of the gas should be at least per cent. This means that the proportion of sulphur to cubic pace is 4 lb per 1 000 cubic feet. A lesser quantity should not e used because it is a practical impossibility to make the average t-infested building air-tight so that a good deal of the gas is st and what remains is diluted by the entry of air The building hould be left full of gas for six to eight hours.
Neighbouring buildings, too should be dealt with as a prevent re measure. A thorough inspection should be made of them, oors opened up and rat runs destroyed or filled in with the ixture of cement and broken glass already mentioned. In towns o new buildings should be erected unless they are to be so onstructed as to make them reasonably rat proof
Indirect measures against the rat also help in limiting an

outbreak of human plague. The regular removal of house refuse and the prohibition of the keeping of animals in inhabited areas tend to make towns unattractive to rats. The storage of food stuffs in metal rat proof containers may be recommended with the same object. Grain should be stored in rat proof go-downs or granaries.

Poisoning of Rats.—Even when rat-proof premises have been erected and cleansing services established the problem remains of keeping the premises rat free. Whatever the local authority may do the habits of the people may completely neutralise the beneficial effects of the measures which the Local Authority has been able to take. The poorer a population the more over crowding there is, and the more tendency is there for the hoarding of what appears to the inspector to be miscellaneous rubbish of no conceivable value. All this encourages rat infestation so that resort must be had to poisoning to keep the rats down in numbers.

There are certain fundamental matters of procedure which are necessary to the success of a rat poisoning campaign. They are, briefly the following

(*a*) The unit for treatment should not be less than a city block in large towns though smaller units may be successfully handled in smaller places.

(*b*) The occupiers of the area to be treated should be fully informed of what the Health Department propose to do and how they propose to set about it. This is best effected by enlisting the help of the local press and by holding evening meetings in the area where the whole matter can be explained to those concerned. At these meetings the people should be told what they are expected to do or to refrain from doing

(*c*) A study should be made in collaboration with the Veterinary Department if such exists, of the habits of the local rats especially with regard to their nests, runs and kind and sources of food and water

(*d*) Preliminary baiting with unpoisoned baits should be carried out for several days before the poisoned baits are laid. The objects of this are to get the rats accustomed to the food which will later be used as the vehicle for the poison, and to arrive at an estimate of the quantity which will be necessary to treat the area.

(*e*) Enough poison should be incorporated in each bait to make sure of the death of the rat which consumes it. If insufficient

doses of poison are taken the rats which recover from the poison ing are unlikely to eat another bait for a very long time.

Rat poisons—There is quite a variety of rat poisons on the market. Those which consist of cultures of living virus, e.g the Danysz virus are not quite suitable for use in the tropics and are not so effective as Barium Carbonate and Alpha napthyl thiourea known for short, as A.N T U These are both deadly to rats in doses which are harmless to domestic animals. The killing dose of barium carbonate is 3 grains whereas that of A.N T U is about 6 mg Barium carbonate is effective for all kinds of rat, but A.N T U is very much more poisonous to the grey rat *Rattus Norvegicus*, than it is to the brown *R. Alexandrinus* or the black, R.r rattus. When the rat population is predomin antly *R. Norvegicus* A.N T U is the poison of choice, where it is mixed or predominantly R.r rattus or R.r Alexandrinus barium carbonate should be preferred.

Barium carbonate is a heavy white powder It is best used incorporated in a dough formed from the flour of the grain in common use in the locality Each bait should contain 3 grains of the poison. It may also be incorporated in tallow or other fats. A.N T U is supplied as a fine bluish grey powder It is insoluble in water and stable to heat. It has no perceptible smell and only a fugitive bitter taste. It mixes evenly with all kinds of food and adheres well to dry or damp foods when dusted on them. It dusts well from insect dust sprayers and pumps.

It must be eaten to produce its effect which is to cause an acute oedema of the lungs from which the rats die within ten to twenty four hours. It is not an accumulative poison and after recovering from a sub-lethal dose the rat may develop a tolerance to further quantities of the poison which lasts about thirty days and an aversion to it which may last several months. (Richter and Emlen.)

A.N T U may be used in a number of ways

(*a*) Thoroughly mixed with finely ground grain in the proportion of three parts A.N T U to 100 parts grain. The mixture is distributed in small shallow piles.

(*b*) Dusted as a thin film on the surface of water which has been placed in convenient containers.

(*c*) Pieces of fruit tomatoes, fish heads, chicken heads, and the surrounding area for a distance of about 6 inches are dusted with A.N T U from a spray gun or shaker

The disease is probably as old as the human race, and in ancient times few persons could have escaped it.

The cause of the disease is a filter passing virus, which is present in the skin lesions in all stages of the disease. It does not appear to be very robust, since it can be destroyed by the ordinary processes of disinfection, but it has an extraordinary resistance to drying. Dried pus from a smallpox pustule keeps its infectivity for years.

Incubation Period.—Long—average twelve days, range eleven to seventeen days.

Liability to Epidemic Spread.—In unvaccinated communities it is notoriously liable to cause widespread epidemics.

Period of Infectivity of the Patient.—The patient is infectious throughout his illness and until all the scabs and crusts have disappeared from the skin.

Carrier State.—The carrier state does not seem to occur with smallpox.

Channels of Infection.—The patient is the source of the infection, which occurs in the lesions of the skin and mucous membranes of the nose and mouth.

From the patient the disease may be spread from scurf and dried scabs in the form of infectious dust. Bedclothing and dressings soiled by the patient may harbour the infection in active form for a long time unless they are disinfected.

Prevention.—The patient should be isolated and nursed in a special smallpox hospital.

All bedding and clothing used by the patient before his removal to hospital should be disinfected by steam under pressure, or if this is not available, by boiling. Bedding which cannot be properly disinfected should be burnt.

Vaccination.—The above mentioned measures could not be applied soon enough to prevent an outbreak. What has caused smallpox to disappear from parts of the world where it was formerly rife has been the immunising process known as *vaccination.*

It has long been known that smallpox could be produced by the process known as *variolation*, which is the inoculation into the skin, or mucous membrane of the nose, of pus obtained from a smallpox patient. When the disease was induced in this way it was found to be mild and this mild attack protected the patient from subsequent attacks of the severe form. For centuries

the Chinese have practised variolation by scratching the mucous membrane of the nose with a sharp bone instrument, the point of which has been dipped in the pus of a smallpox pustule. In Arabia the variolator uses a sharp thorn similarly coated with the virus which he inoculates by scarifying the skin.

In the early seventeenth century the practice of variolation was introduced in Europe, and in time a number of principles were laid down for its successful performance (*a*) only clean lymph obtained from vesicles four to five days old was used (*b*) the lymph was always obtained from another case of inoculated smallpox and not from the natural disease, (*c*) only mild cases were used as sources of lymph, (*d*) the lymph was stored dry on threads, lint or sponges and introduced into a cut made in the skin.

The disadvantages of variolation are (1) that a patient suffering from the mild variolated form might give rise to the disease in severe form in other persons, (2) that diseases other than small pox may be transmitted in the process, (3) the smallpox produced by variolation might, in a certain proportion of cases, be just as severe and disfiguring as the natural disease.

Cowpox.—It was common knowledge among country people that persons who contracted from cattle the mild disease known as cowpox did not suffer subsequently from the smallpox. On May 14 1796 Dr Edward Jenner performed his first vaccination on a boy with cowpox matter obtained from a milkmaid suffering from this disease. Two months later he inoculated the boy with smallpox and found that he was insusceptible to it. Jenner made further experiments which soon revealed to him that in cowpox he had a valuable means of immunising persons from the dreaded smallpox. The process of inducing artificially in human beings the disease known as cowpox is known as *vaccination*.

The advantages of vaccination over variolation were quickly appreciated. The disease so induced was almost invariably mild the risk of conveying other diseases was negligible and the protection afforded against smallpox was as great as by variolation. The human being was quickly discarded as the source of vaccine lymph which was instead prepared from healthy calves.

In the preparation of the lymph a healthy calf is selected and well groomed. The hair over the abdominal skin is then shaved and the animal is vaccinated by means of a number of long scratches on the shaved area into which the vaccine is well

The disease is probably as old as the human race, and in ancient times few persons could have escaped it.

The cause of the disease is a filter passing virus, which is present in the skin lesions in all stages of the disease. It does not appear to be very robust, since it can be destroyed by the ordinary processes of disinfection, but it has an extraordinary resistance to drying Dried pus from a smallpox pustule keeps its infectivity for years

Incubation Period.—Long—average twelve days, range eleven to seventeen days.

Liability to Epidemic Spread.—In unvaccinated communities it is notoriously liable to cause widespread epidemics.

Period of Infectivity of the Patient.—The patient is infectious throughout his illness and until all the scabs and crusts have disappeared from the skin.

Carrier State—The carrier state does not seem to occur with smallpox.

Channels of Infection.—The patient is the source of the infection, which occurs in the lesions of the skin and mucous membranes of the nose and mouth.

From the patient the disease may be spread from scurf and dried scabs in the form of infectious dust. Bedclothing and dressings soiled by the patient may harbour the infection in active form for a long time unless they are disinfected.

Prevention.—The patient should be isolated and nursed in a special smallpox hospital.

All bedding and clothing used by the patient before his removal to hospital should be disinfected by steam under pressure, or if this is not available, by boiling Bedding which cannot be properly disinfected should be burnt.

Vaccination.—The above-mentioned measures could not be applied soon enough to prevent an outbreak. What has caused smallpox to disappear from parts of the world where it was formerly rife has been the immunising process known as *vaccination.*

It has long been known that smallpox could be produced by the process known as *variolation*, which is the inoculation into the skin, or mucous membrane of the nose, of pus obtained from a smallpox patient. When the disease was induced in this way it was found to be mild and this mild attack protected the patient from subsequent attacks of the severe form. For centuries

the Chinese have practised variolation by scratching the mucous membrane of the nose with a sharp bone instrument, the point of which has been dipped in the pus of a smallpox pustule. In Arabia the variolator uses a sharp thorn similarly coated with the virus which he inoculates by scarifying the skin.

In the early seventeenth century the practice of variolation was introduced in Europe, and in time a number of principles were laid down for its successful performance (*a*) only clean lymph obtained from vesicles four to five days old was used, (*b*) the lymph was always obtained from another case of inoculated smallpox and not from the natural disease, (*c*) only mild cases were used as sources of lymph, (*d*) the lymph was stored dry on threads, lint or sponges and introduced into a cut made in the skin.

The disadvantages of variolation are (1) that a patient suffering from the mild variolated form might give rise to the disease in severe form in other persons, (2) that diseases other than smallpox may be transmitted in the process, (3) the smallpox produced by variolation might, in a certain proportion of cases, be just as severe and disfiguring as the natural disease.

Cowpox.—It was common knowledge among country people that persons who contracted from cattle the mild disease known as cowpox did not suffer subsequently from the smallpox. On May 14 1796 Dr Edward Jenner performed his first vaccination on a boy with cowpox matter obtained from a milkmaid suffering from this disease. Two months later he inoculated the boy with smallpox and found that he was insusceptible to it. Jenner made further experiments which soon revealed to him that in cowpox he had a valuable means of immunising persons from the dreaded smallpox. The process of inducing artificially in human beings the disease known as cowpox is known as vaccination.

The advantages of vaccination over variolation were quickly appreciated. The disease so induced was almost invariably mild the risk of conveying other diseases was negligible and the protection afforded against smallpox was as great as by variolation. The human being was quickly discarded as the source of vaccine lymph which was instead prepared from healthy calves.

In the preparation of the lymph a healthy calf is selected and well groomed. The hair over the abdominal skin is then shaved and the animal is vaccinated by means of a number of long scratches on the shaved area into which the vaccine is well

rubbed. About a week after vaccination the vesicles which have formed along the scratches are scraped off, thoroughly ground up in a mortar mixed with glycerine which acts as a preservative and also as mild antiseptic against bacterial contamination, and stored in a cool chamber for subsequent use. When the lymph has been removed, the calf is killed and a careful post mortem examination is made to ascertain that the animal is really healthy If the animal is found to be diseased the batch of lymph obtained from it is destroyed.

Before the lymph is issued for use it is carefully tested to make sure that it does not contain tetanus bacilli (the cause of the disease known as lockjaw), the virus of foot and mouth disease or any other organisms which would render it unfit for use. If it is found to be innocuous it is then tried on a rabbit as a last test before issue.

The Effects of Vaccination.—Smallpox used to be so dreaded that at one time the possession of a well-pitted face was an almost essential qualification in anyone applying for a post of domestic servant. Employers knew that the chance of such a person contracting smallpox a second time was practically negligible. Compulsory vaccination of the whole population is the only way by which a nation may be efficiently protected against smallpox. The example of Germany is frequently quoted in this respect. A law requiring the compulsory vaccination of infants within one year of birth was enacted in 1874 Before this law was passed smallpox was a serious public health problem in the country In 1897 there were only eight deaths from smallpox in the German Empire on a population of 54 000,000

The protective value of vaccination is seen in the change in the age incidence of the disease in a well vaccinated community as compared with the age incidence in the same community before vaccination. Over 90 per cent. of the deaths from smallpox in an unvaccinated community occur in children under twelve years of age. In the same community after vaccination has been made universal, over 90 per cent. of the deaths occur in persons over forty years of age.

Vaccination confers immunity against smallpox from about the tenth day onwards. If therefore, an unvaccinated contact is vaccinated as soon as possible after his exposure to infection he may be protected from an attack, or if he should become attacked the probability is that the disease will be mild The

ater he is vaccinated after exposure to infection the less chance here is of his being protected.

The immunity to smallpox given by vaccination lasts for about even years. Revaccination should be made about this time. The second vaccination will probably make the person immune o smallpox for the rest of his life.

The staffs of smallpox hospitals or of the public health author ty dealing with smallpox should be revaccinated more frequently

In vaccination we have therefore a measure for the practical elimination of a disease which at one time was one of the common pestilences affecting mankind. It is the only practicable method of control on a large scale, and if it is practised extensively it can undoubtedly reduce the problem of smallpox control to very small proportions.

It is claimed that vaccination will—

(a) give reasonable immunity to smallpox for some seven years

(b) so modify smallpox, if contracted, that the disease will be mild

(c) re-establish immunity indefinitely by being successively applied every seven years

(d) confer complete protection to a community if every person is vaccinated.

Rabies

Rabies is an acute specific infection communicated from an infected animal to a healthy one usually by biting, though it may be spread by licking Man generally becomes infected through the bite of a rabid dog but he may also contract the disease if an infected animal should lick him and the saliva come into contact with a small scratch or other wound in the skin.

All mammals are susceptible to rabies. In most places man gets his infection from the domestic dog or cat. Recently however in Trinidad and in certain parts of South America the vampire bat has been found to transmit the disease to human beings and cattle.

The disease is endemic practically all over the world with the exception of Australia where it is unknown. In most places the wild animals, such as jackals, foxes and wolves, act as the reservoirs of the infection.

Rabies in the Dog—A domestic dog infected with rabies becomes uneasy, his disposition changes and he may snap at his master. He is irritable and may swallow articles like stones or pieces of wood. He becomes restless and may try to hide himself, snarling or snapping at anyone who comes near him even if the person should be known to him. Occasionally he may travel long distances, very excited, frothing at the mouth and snapping at anything in his way. Paralysis afterwards sets in, affecting the legs and lower jaw and death generally follows.

The *incubation period* in man is long—from fourteen days to about two years.

When once the disease has established itself there is no known treatment which will effect cure. The only hope for the patient is the institution of anti-rabic inoculation as soon as possible after he has been bitten. Anti rabic inoculation consists of a series of hypodermic injections of the patient with a suspension of weakened or killed rabies virus. The treatment takes from a fortnight to three weeks and is given at a central laboratory where the injection material is prepared. The sooner the injections are begun the better but owing to the long incubation period of the disease the patient has generally a week or ten days in which to get from his home to the laboratory

The prevention of rabies in man rests in controlling domestic dogs, and in causing persons bitten by dogs or other animals suspected of being infected to undergo a course of anti rabic treatment. The dogs can be controlled by causing them to be muzzled and prevented from associating with pariah dogs, jackals or other predatory animals in the vicinity

When a domestic dog bites a person in an area in which rabies is endemic the dog should be kept under veterinary observation for ten days. If at the end of this period the dog shows no signs of ill health it is not necessary for the person who was bitten to undergo a course of treatment. The reason for this is that the virus appears in the saliva of the infected animal only about five days before the onset of symptoms of the disease. If no signs of the disease appear in the animal within ten days of its having bitten a person, the probability is that the bite was not infected. If however the dog shows signs of rabies, the bitten person should be treated at once.

The following is a good rough indication as to when a person bitten by a dog jackal or other wild animal should be sent for anti rabic treatment

(a) In every case in which a jackal or other wild animal has bitten the person.

(*b*) When the dog is thought to be infected.

(*c*) Where the dog is unknown and has disappeared after biting the patient.

(*d*) If the dog has been killed or dies within ten days after having bitten the patient.

If a laboratory diagnosis of rabies in a suspected animal is required the brain must be sent to the laboratory for examination. When a domestic dog is concerned, the animal should be kept under observation for ten days. If he shows signs suggestive of rabies during that time he should be killed.

The head of the dead animal should be carefully washed with a good disinfectant (corrosive sublimate 1/500 or a 1 per cent. solution in water of one of the coal tar group) With a sharp knife an incision is made down to the bone along the middle line of the head, beginning at the muzzle and cutting backwards over the brow to the back of the head. The skin and underlying tissues are then reflected back and the skull exposed. With a hammer and chisel the skull is opened, care being taken not to damage the brain. When a sufficient opening has been made the membranes covering the brain are cut open and the brain is removed from the skull, the nerves and the spinal cord being severed. If the brain is gently lifted from the front and freed by cutting the nerves coming from the under surface and lastly the spinal cord, it will come away whole. After the brain is removed it is divided into two halves by cutting between the two hemispheres. The cut portions of the brain are then put into a large jar containing a preservative fluid made up as follows Potassium bichromate 5 drachms, perchloride of mercury 7 drachms, glacial acetic acid 7 drachms and water 20 oz. The quantity of this fluid necessary for the proper preservation of the brain is about ten times the volume of the brain itself. The jar is then carefully stoppered and sent to the labor atory A label written in graphite pencil should be included with the specimen, containing the following information

1 Kind of animal (dog, jackal, meercat etc.)

2. Place animal found.

3 Date of removal of the specimen.

4 Examination required (e.g rabies)

5 Reference to the correspondence (e.g my letter No dated *Re* John Smith).

6. Name of officer transmitting the specimen.

The specimen should be accompanied by a letter giving full details of the circumstances necessitating the investigation.

The inspector should usually leave all such *examinations to* be performed either by a medical or veterinary officer It may happen, however that neither is available, in which case the inspector may have to carry on. Special care should be taken to prevent the saliva of the animal or the brain tissue from coming into contact with the operator's hands and he should *disinfect* his hands thoroughly in a 1/500 solution of perchloride of mercury after the dissection has been made, whether he wears rubber gloves or not. The dissection should be made as soon after the death of the animal as possible.

Rabies has been kept out of Australia by the rigorous imposition of a six months quarantine on imported dogs.

Yaws

Yaws is a very common disease in some parts of the tropics. It is caused by a spirochete known as the *Spironema pertenue* and produces a scabby eruption on the skin, ulceration, and destruction of tissues, especially those of the mouth. The disease is a very chronic one, lasting for years. At first it is confined to the skin, but later the mouth and bones are involved.

Distribution.—The disease is common in the West Indies, tropical Africa, Ceylon, Burma and Assam. It is extremely common in Oceania. It occurs also in China.

Transmission.—The disease is conveyed by direct *contagion* from the sick to the healthy It is a disease of the overcrowded and unhygienic. In endemic areas few of the indigenous population escape.

Prevention.—In endemic areas isolation of the sick is practically *impossible on account of the huge numbers* involved. The most hopeful means of controlling the disease is by the institution of treatment clinics. This has become possible by the discovery of drugs such as salvarsan and certain preparations of bismuth, which offer practically certain cure with little risk. Recently penicillin has been favourably reported on as a useful means of treatment. While the treatment campaign is in progress the sanitary staff can give valuable help in advising the inhabitants regarding the importance of personal cleanliness, avoidance of overcrowding, providing suitable bathing places and emphasising the need for medical consultation whenever the disease is suspected.

Anthrax

Anthrax is an acute and serious disease caused by the anthrax bacillus. In man it occurs as a skin infection known as malignant pustule, which resembles a very severe boil or carbuncle as gastro-intestinal anthrax, or as pulmonary anthrax. The disease attacks most farm animals horses, cattle, sheep goats and pigs. The bacillus is one of the spore bearing bacilli the spores of which can live for a long time outside the animal body When they gain access to the body they give rise to bacilli again and cause the disease. Pastures may become infected from infected animals and remain infected for long periods. By inoculating stock with anthrax vaccine and by the use of the measures described below the disease has been practic ally stamped out in civilised countries, but it is still common in the tropics.

Incubation Period.—Seven to ten days.

Liability to Epidemic Spread.—Not liable in human beings. It is an occupational disease, being found more frequently among those who tend domestic animals, or those who work with hides and skins.

Period of Infectivity of Patient.—The patient is infectious throughout his illness.

Carrier State—Not known in man.

Channels of Infection.—Man becomes infected from the hair skin, or flesh of an infected animal. The infection may linger in the hair wool, or skin for a considerable time. Shaving brushes made from unsterilised infected bristles have caused outbreaks and cases have occurred among workers handling infected wool or hides. I once saw a case caused by the consumption of meat from a carcass of an ox dead of the disease.

Prevention.—Isolation of the patient. Destruction by fire of all soiled dressings. Sterilisation of the patient's clothing by steam under pressure.

Isolation of affected animals. Destruction of infected car casses by fire or by burial 6 feet deep in quicklime. The skin of an animal dead of anthrax should on no account be cut or the blood let, since this would let the infection, which is a blood infection, pollute the ground and might make it difficult to eradi cate from the place. All infected premises should be scrupu lously disinfected When it occurs at a dairy the sale of milk

should be stopped until the infected animal has been removed and the others kept under observation long enough to give them a clean bill of health.

Rat Bite Fever

This infection is contracted by man through the bites of rats or cats. It is merely an occasional infection and shows no epidemic tendency The preventive measures applicable are those directed to the elimination of rats from dwelling-houses.

Guinea Worm Infection (Dracontiasis)

The Guinea worm, *Dracunculus medinensis* is a fairly common parasite in certain localities in Tropical Africa, the Nile Valley Arabia and India. The female is the cause of the disablement. She burrows under the skin and eventually comes to rest in some dependent part, usually the ankle, but I have seen them on the chest.

Transmission.—Infection results from swallowing water containing the infected intermediate host of the worm, a small crustacean known as Cyclops. The following account explains how the cyclops become infected.

The female guinea worm is nearly three feet long and about a twenty fifth of an inch thick. By the time she reaches the skin of man most of the interior of her body is occupied by the uterus which is full of countless embryo worms which can be seen only when magnified by the microscope. On coming to rest under the skin she extrudes a very irritant fluid which causes destruction of the skin from underneath and, eventually the formation of an ulcer in the bottom of which the front end of the worm may be seen lying in a little pore. If the ulcer is douched with cold water a drop of milky fluid will be seen to ooze from the pore in which the worm is exposed. On examination under the microscope this milky fluid is seen to contain large numbers of living, actively moving embryo worms.

The burning pain caused by the ulcer makes the patient instinctively douche the affected part with water or immerse it in water This causes the extrusion of embryos by the female worm and if these embryos should gain access to water in which is living the tiny crustacean known as Cyclops they are swal-

lowed by this creature. Being swallowed does not affect the embryos injuriously on the contrary they grow in the stomach of the Cyclops and eventually swarm into its body cavity.

After a month or six weeks in the body cavity of the Cyclops the larvae have become capable of development in man. Man is infected by swallowing infected Cyclops in his drinking water. On entering the human stomach the Cyclops are killed, but the guinea worm larvae are unaffected. They make their way out of the body of the cyclops into the stomach contents. Eventually they bore through the wall of his alimentary canal and find their way to the connective tissues where they develop into adult worms. After pairing the pregnant females make their way to the surface of the body and cause the ulcer in the manner already described.

Note that there is no danger of human infection from water contaminated with larval guinea worms so long as there are no cyclops present. Growth in the cyclops is a necessary step to the development of the capacity to infect man.

Prevention.—The prevention of guinea worm infection rests entirely with the protection of water supplies from discharges from guinea-worm ulcers or from infestation by cyclops. It is an infection associated entirely with unprotected wells or tanks or with the habit of drinking water from watering holes and similar collections of water exposed to pollution of all kinds. It disappears from areas after the water supply has been made safe. When water from unprotected sources must be drunk, boiling it is the best means of making it safe.

Typhus Fevers

There is a group of fevers known as the typhus fevers. In some parts of the world they are transmitted by lice (the louse borne typhus of Europe, the Middle East, Northern Africa and India and China); in other parts they are transmitted by ticks (the Rocky Mountain fever occurring in states near the Rocky Mountains and the tick typhus of India). The prophylactic measures applicable to them are exactly the same as those described with regard to louse and tick borne relapsing fevers (see page 116).

ducted through the substance and this manner of conveying heat is known as *conduction*. A substance which offers little obstruction to the flow of heat is known as a good conductor one which obstructs the flow is known as a bad conductor or *insulator* When a substance such as a fluid or a gas conducts heat by the flow of its own substance, the warmer parts flowing into and warming the cooler the transference of the heat is known as *convection*.

Latent Heat.—All inanimate matter on the earth can exist in the form of a solid, a liquid, or a gas. When matter is in the solid state the minute particles composing it, which are known as *atoms* are close to one another and are arranged in some definite geometrical pattern depending on the nature of the substance. If energy is applied to the solid in the form of heat this energy is utilised in increasing the internal vibration of the atoms and *causes the substance to expand and its temperature to rise. This* rise of temperature can be measured by a thermometer But there comes a time when the further addition of heat makes no difference to the temperature of the substance. Instead of a rise of temperature occurring as hitherto, the substance loses its rigidity and becomes fluid in other words, it melts. The energy applied to it in the form of heat has been used in overcoming the energy binding the atoms together with the result that rigid structure is lost and a liquid occurs. Two or more atoms usually remain linked together to form what are called molecules which, although still close together can move independently The heat which has been used in bringing about the change of state from solid to liquid is called *latent* or *hidden* heat because it cannot be revealed by a change in the temperature of the substance and shewn by the thermometer

When a liquid is cooled and allowed to solidify suddenly a rise in its temperature occurs because of the sudden cessation of movement in the particles composing it and the linking up of the atoms to form a solid again. This is merely the conversion of one kind of energy into another just as the energy of a rapidly *moving* rifle bullet is converted into heat when the bullet is suddenly stopped by striking a rigid steel plate.

A further change of state occurs when a liquid is changed into a vapour We have already seen that in a liquid the molecules of the substance are constantly moving but maintaining some sort of cohesion owing to attractive forces between them. But the

speed at which the molecules move is variable, some moving more quickly than others, and in the layers of molecules forming the surface of the liquid a more energetic molecule will suddenly escape from its fellows, leave the liquid and become mingled with the molecules of the atmosphere. If this process is allowed to go on unchecked the liquid will eventually dry up that is, be wholly converted into vapour This process is known as *evaporation* and it is what happens when a saucer of water is exposed to the air for some time.

The escape of the more rapidly moving molecules of the liquid causes a loss of energy and consequent fall of temperature, which, however is not evident in the case of the saucer of water because the evaporation is so slow that the heat lost is at once restored from the surrounding air and the saucer itself If however the surface of the water is greatly increased by containing it in a porous earthenware vessel whose pores the water can penetrate and so have a large surface in contact with the air evaporation takes place so rapidly that the water in the vessel may be cooled several degrees below the temperature of the air

If water is heated the heat imparted to the water increases the speed at which the molecules move. Consequently the temperature rises and evaporation proceeds more quickly If the heating is continued the movement of the molecules will become so rapid and they will escape from the surface in such large numbers that the layer of air above the liquid will be pushed back, and myriads of molecules will leave the water simultaneously in other words the water boils and the heat imparted to it will not now be used to raise its temperature but to bring about this change of state from liquid to vapour This heat is called the latent heat of vaporisation.

The amount of latent heat concerned in these changes is considerable. At atmospheric pressure the latent heat of melting ice is about 79 calories per gramme while the latent heat of vaporisation of water amounts to between 536 and 537 calories per gramme.

We have seen that when a solid substance is heated it expands. A very much greater expansion happens when a liquid becomes a vapour (or gas). When water becomes vapour (steam) the increase in volume which occurs is about 1 700 times. But what concerns us in this place is not so much what happens when

water becomes steam but what happens when steam becomes water again.

Steam at atmospheric pressure has a temperature of 100 C. When it is brought into contact with a substance whose temperature is a good deal less than 100° C. the latent heat of the steam immediately flows into the cooler substance. On being suddenly deprived of the energy represented by the latent heat the molecules of the steam which, by that energy were being kept wide apart and in very vigorous movement, almost instantaneously come together and slow down. The steam has become water again, or as an engineer would say has *condensed*. The great shrinkage in volume which takes place when this happens (from 1 700 to 1) leaves a vacuum at the place of condensation. This vacuum is filled by the inrush of the surrounding atmosphere. The substance on which condensation takes place is therefore wetted with the water and warmed by the latent heat of evaporation which has flowed into it from the steam. If the temperature of the substance on which condensation is taking place remains below the temperature of the boiling point of water more steam condenses on it, and this process goes on until either the substance is raised to a temperature of 100 C. or until all the steam has condensed.

Practical Application of Heat. Burning.—Burning will entirely destroy bacteria. It is the most reliable and serviceable means we have of disposing of infected articles of little or no value, such as infected stools, dressings, rags, papers and room sweepings.

Dry Heat.—Dry heat conveyed by the radiation of heat from a hot iron such as tailors or laundrymen use, or by a current of hot air is practically never used in routine disinfection. Objections to the use of dry heat are (*a*) the difficulty of maintaining an even temperature in the material to be disinfected (*b*) the difficulty of keeping the material at the disinfecting point without damaging it and (*c*) the feeble penetrative power of hot air

Moist Heat.—Moist heat is the term given to heat which is conveyed to the material to be disinfected by means of water or steam. Water as a vehicle has many advantages. It is easily obtainable over a wide area of the inhabited globe, it is a convenient conductor of heat and when it is in the form of steam it is very penetrative. A fabric can be entirely penetrated by steam and heated without damage when it could not be satisfactorily

treated with hot air While water is boiling at atmospheric pressure its temperature remains steady at a point where most pathogenic organisms are killed in a few minutes. This useful property of water enables disinfection to be carried out reliably without the use of special apparatus and so extends its range of usefulness. Steam also remains at a steady temperature so long as it is in contact with the water from which it is being given off Boiling water and steam are therefore widely employed in the disinfection of textiles, fabrics, clothing cutlery and other objects which can withstand boiling without damage.

Boiling water and steam are *not* suitable for the disinfection of furs, leather goods, books, knives or other cutlery having handles fixed with cement, coloured fabrics in which the dye runs with wetting, fabrics such as knitted woollen goods and flannels, which shrink when boiled, and objects containing glue, wax, varnish or rubber

Simple *boiling* is a most effective means of disinfecting small objects and garments. When garments have been soiled with the discharges from a patient they should be steeped in cold water until the stains have come out before they are boiled, since many such stains become permanent if the garment is boiled without prior removal. A suitable receptacle, water and a good fire are all that are needed. An empty petrol-tin makes an excellent vessel for the boiling of utensils, bedpans, crockery and other small objects contaminated by the patient. Glassware may be boiled without damage if it is put on cold and brought to the boil and if it is approximately of the same thickness throughout. Water jugs having thick glass handles should not be boiled because they are very liable to crack with the heat. Filter candles are sterilised by boiling.

To disinfect articles by boiling, the water in which the articles are immersed should be kept boiling vigorously for twenty minutes.

Steam.—Steam is the most generally employed disinfecting agent for operations on a large scale. It has the advantage of being able to penetrate rapidly into the substance of a fabric so that the whole fabric becomes evenly heated throughout. The temperature of steam remains steady so long as it is in contact with the water from which it is being generated. This temperature can be raised to any required degree by increasing the pressure under which it is generated or by adding salts to the

water becomes steam but what happens when steam becomes water again.

Steam at atmospheric pressure has a temperature of 100° C. When it is brought into contact with a substance whose temperature is a good deal less than 100° C. the latent heat of the steam immediately flows into the cooler substance. On being suddenly deprived of the energy represented by the latent heat the molecules of the steam which, by that energy were being kept wide apart and in very vigorous movement, almost instantaneously come together and slow down. The steam has become water again, or as an engineer would say, has condensed. The great shrinkage in volume which takes place when this happens (from 1 700 to 1) leaves a vacuum at the place of condensation. This vacuum is filled by the inrush of the surrounding atmosphere. The substance on which condensation takes place is therefore wetted with the water and warmed by the latent heat of evaporation which has flowed into it from the steam. If the temperature of the substance on which condensation is taking place remains below the temperature of the boiling point of water more steam condenses on it, and this process goes on until either the substance is raised to a temperature of 100 C. or until all the steam has condensed.

Practical Application of Heat. Burning.—Burning will entirely destroy bacteria. It is the most reliable and serviceable means we have of disposing of infected articles of little or no value, such as infected stools, dressings, rags, papers and room sweepings.

Dry Heat.—Dry heat conveyed by the radiation of heat from a hot iron such as tailors or laundrymen use, or by a current of hot air is practically never used in routine disinfection. Objections to the use of dry heat are (*a*) the difficulty of maintaining an even temperature in the material to be disinfected (*b*) the difficulty of keeping the material at the disinfecting point without damaging it and (*c*) the feeble penetrative power of hot air

Moist Heat.—Moist heat is the term given to heat which is conveyed to the material to be disinfected by means of water or steam. Water as a vehicle has many advantages. It is easily obtainable over a wide area of the inhabited globe, it is a convenient conductor of heat and when it is in the form of steam it is very penetrative. A fabric can be entirely penetrated by steam and heated without damage when it could not be satisfactorily

treated with hot air While water is boiling at atmospheric pressure its temperature remains steady at a point where most pathogenic organisms are killed in a few minutes This useful property of water enables disinfection to be carried out reliably without the use of special apparatus and so extends its range of usefulness. Steam also remains at a steady temperature so long as it is in contact with the water from which it is being given off Boiling water and steam are therefore widely employed in the disinfection of textiles, fabrics, clothing cutlery and other objects which can withstand boiling without damage.

Boiling water and steam are *not* suitable for the disinfection of furs, leather goods, books knives or other cutlery having handles fixed with cement, coloured fabrics in which the dye runs with wetting fabrics such as knitted woollen goods and flannels, which shrink when boiled, and objects containing glue wax, varnish or rubber

Simple *boiling* is a most effective means of disinfecting small objects and garments. When garments have been soiled with the discharges from a patient they should be steeped in cold water until the stains have come out before they are boiled, since many such stains become permanent if the garment is boiled without prior removal. A suitable receptacle water and a good fire are all that are needed An empty petrol-tin makes an excellent vessel for the boiling of utensils bedpans, crockery and other small objects contaminated by the patient. Glassware may be boiled without damage if it is put on cold and brought to the boil and if it is approximately of the same thickness throughout. Water jugs having thick glass handles should not be boiled because they are very liable to crack with the heat. Filter candles are sterilised by boiling

To disinfect articles by boiling, the water in which the articles are immersed should be kept boiling vigorously for twenty minutes.

Steam.—Steam is the most generally employed disinfecting agent for operations on a large scale. It has the advantage of being able to penetrate rapidly into the substance of a fabric so that the whole fabric becomes evenly heated throughout. The temperature of steam remains steady so long as it is in contact with the water from which it is being generated. This temperature can be raised to any required degree by increasing the pressure under which it is generated or by adding salts to the

water since the temperature of the steam is always the same as that of the water from which it rises. The effect of pressure on the temperature at which water boils (the boiling point) is seen in the following table

Pressure above atmospheric pressure	Pounds to square inch	Boiling point of water in degrees Centigrade
0 atmosphere	nil	100°
⅓	5	109°
⅔	10	115 5°
1 ,,	15	121 5°

The successful use of steam requires special apparatus (*a*) a steam generator (*b*) an air tight and preferably insulated chamber to hold the steam and the articles to be disinfected.

The Penetrative Power of Steam.—The ability of steam rapidly to spread through a porous substance and heat it is known as the penetrative power of steam. It depends upon two things (*a*) the great reduction in volume which takes place when steam condenses, and (*b*) the amount of latent heat set free on condensation. When steam at 100° C. is admitted to the chamber containing the articles to be disinfected it meets the cool outer layer of the articles and condenses on it. At that moment, as we have already seen, two things happen (1) its latent heat suddenly flows into the cooler substance and rapidly heats it up (2) the steam turns to water which takes up only one seventeen-hundredth part of the space occupied by the steam. More steam, therefore, rushes into the space caused by the condensation, again gives up its latent heat to the substance, again condenses and so on until the article or fabric is permeated with steam and is at the same temperature as the steam itself.

Streaming Steam or Current Steam is steam given off by water at atmospheric pressure. Pressure steam is steam which is given off by water boiled under pressure. The use of pressure steam requires a gas-tight system of boiler tubes and disinfecting chamber since, in order to keep at the same temperature as the boiling water the steam must be kept at the same pressure. The advantage of pressure steam is that it is at a temperature higher than 100 C. according to the pressure under which it is generated and is therefore effective in a shorter time than *streaming* steam. The greatest advantage of it is, however that it enables

us easily to reach a temperature of 120° C., which will kill spores in a few seconds

The time of sterilisation by both streaming (or current) steam and pressure steam is about the same in practice, i.e. twenty minutes.

Air Pockets.—We have already seen that air is a bad conductor of heat. If it is allowed to remain in a fabric which is to be steamed air pockets will form in the article which will resist penetration by the steam and the fabric contained in the pockets will not obtain any of the latent heat because the steam is prevented from condensing on it. This may result in parts of an article not being disinfected at all, especially if the article is bulky—for example a mattress When current steam is being used the air in the fabric may be driven out by admitting the steam at the top of the chamber and providing an opening at the foot for the exit of the air The incoming steam drives before it the colder air which tends to sink. If the steam were to be admitted from the bottom of the chamber the air would be warmed, rise, and form pockets. The disinfecting machines employing steam under pressure are either arranged to dislodge the air by streaming steam before the apparatus is put under pressure, or the air is removed by a suction apparatus known as an ejector

It will have been noted from the account given of the penetrative power of steam that the tighter clothing and bedding are packed, the slower will be the penetration of the steam and the longer will be the time needed for disinfection. The packing of articles to be disinfected should therefore be made as loosely as economical working of the machine will allow

After disinfection has been completed the articles must be dried before being returned to the owners. This may be done by airing them if an improvised disinfector is being used The large disinfecting machines are all fitted with apparatus for the drying of their contents by passing warm air through the chamber

Superheated Steam.—Superheated steam is steam which has been heated above the boiling point of water without altering the pressure under which it is generated. The prefix "super" is so often used nowadays to denote the acme of perfection that one might think that superheated steam would be a better disinfectant than pressure or streaming steam. This is not so The penetrative and disinfecting power of steam depends upon

its condensation, since it is only by condensation that its latent heat becomes available and its volume shrinks. As the condensing point is below the temperature at which the steam was generated and bears no relation to the higher temperature to which it is raised by superheating, the only effect of superheating is to lengthen the time necessary for condensation, since the steam must fall in temperature to the condensing-point before condensation can take place. Therefore the higher its temperature is raised above the condensing-point *by superheating, the* longer will be the time needed for disinfection.

Improvised and Portable Apparatus for Disinfection by Steam

The improvisation of apparatus for disinfection by steam requires the provision of a boiler connected by suitable tubing with a disinfecting chamber A boiler may be rigged up from an empty 5-gallon oil-drum or even an empty petrol tin since the steam will be used as streaming steam and not under pressure. Two 1 inch diameter pipes should be soldered into the tin in line. One of them, serving as a filling pipe and safety valve, should be carried into the interior of the tin to within about 1 inch of the other side. This pipe indicates when the boiler needs refilling, because evaporation of the water to below the level of the end of the pipe will be shewn by the issue of a stream of steam from the top When this happens the boiler should be refilled with boiling water The second pipe serves to convey the steam generated in the boiler to the disinfecting chamber For this purpose it has an elbow bend and it projects only a short distance into the boiler The boiler is set up with the pipes vertical. It is stood over a fire trench or on bricks or stones enclosing a cavity to hold the fuel.

The disinfecting chamber may be improvised out of a barrel or stout packing-case. This is stood upright with the lid on top and a little higher than the angle pipe of the boiler Just below the lid a hole is bored to admit this pipe which is carried into the chamber for a few inches. In the bottom of the chamber a number of holes are bored to allow air and steam to escape.

To work the apparatus, it is connected up The boiler is filled and the fire started. The bedding and clothing to be disinfected are packed loosely into the disinfecting chamber The lid is then shut down over an old blanket or folds of old news

papers so as to make a fairly steam-tight joint. If the hole where the steam pipe enters the chamber leaks badly it may be wiped with clay or mud. Disinfection should be complete ten minutes from the time steam is seen to issue in a steady stream from the container

When such an apparatus has been improvised it is well to give it a trial run with uninfected clothing in the middle of which a small potato or egg has been placed If after the estimated exposure to steam has been given, the egg or potato is found to be cooked, the disinfector is working properly If not, the time of exposure should be determined by further trial until the time

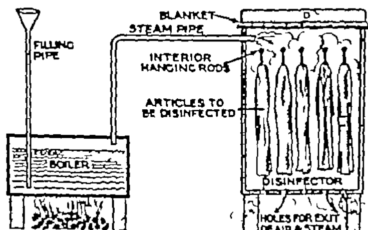


FIG. 21 —An improvised steam disinfector
(*For description see text*)

taken to cook the potato or hard boil the egg has been ascer tained. This will be the time of exposure for the disinfection of clothing by this apparatus.

A good fire is important, because the steam should be gener ated abundantly and steadily As useful a heater as any is one of the large 4-burner kerosene oil stoves working under pressure on the Primus system. For the same reason the boiler should be replenished with boiling water rather than cold.

If hot water blows back through the filling pipe the chamber has been packed too tightly or the steam pipe has become blocked. Heating should be discontinued and the fault found and remedied.

A diagram of an improvised disinfector is given in Fig 21

Portable Apparatus.—The steam sack disinfector This

its condensation, since it is only by condensation that its latent heat becomes available and its volume shrinks. As the condensing point is below the temperature at which the steam was generated and bears no relation to the higher temperature to which it is raised by superheating, the only effect of superheating is to lengthen the time necessary for condensation, since the steam must fall in temperature to the condensing-point before condensation can take place. Therefore the higher its temperature is raised above the condensing point by superheating, the longer will be the time needed for disinfection.

Improvised and Portable Apparatus for Disinfection by Steam

The improvisation of apparatus for disinfection by steam requires the provision of a boiler connected by suitable tubing with a disinfecting chamber. A boiler may be rigged up from an empty 5-gallon oil-drum or even an empty petrol tin since the steam will be used as streaming steam and not under pressure. Two 1 inch diameter pipes should be soldered into the tin in line. One of them, serving as a filling pipe and safety valve, should be carried into the interior of the tin to within about 1 inch of the other side. This pipe indicates when the boiler needs refilling, because evaporation of the water to below the level of the end of the pipe will be shewn by the issue of a stream of steam from the top. When this happens the boiler should be refilled with boiling water. The second pipe serves to convey the steam generated in the boiler to the disinfecting chamber. For this purpose it has an elbow bend and it projects only a short distance into the boiler. The boiler is set up with the pipes vertical. It is stood over a fire trench or on bricks or stones enclosing a cavity to hold the fuel.

The disinfecting chamber may be improvised out of a barrel or stout packing-case. This is stood upright with the lid on top and a little higher than the angle pipe of the boiler. Just below the lid a hole is bored to admit this pipe, which is carried into the chamber for a few inches. In the bottom of the chamber a number of holes are bored to allow air and steam to escape.

To work the apparatus, it is connected up. The boiler is filled and the fire started. The bedding and clothing to be disinfected are packed loosely into the disinfecting chamber. The lid is then shut down over an old blanket or folds of old news

papers so as to make a fairly steam tight joint. If the hole where the steam pipe enters the chamber leaks badly it may be wiped with clay or mud Disinfection should be complete ten minutes from the time steam is seen to issue in a steady stream from the container

When such an apparatus has been improvised it is well to give it a trial run with uninfected clothing in the middle of which a small potato or egg has been placed If after the estimated exposure to steam has been given, the egg or potato is found to be cooked, the disinfector is working properly If not, the time of exposure should be determined by further trial until the time

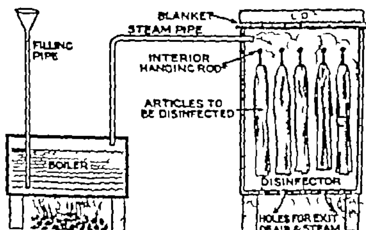


FIG. 21 —An improvised steam disinfector
(*For description see text*)

taken to cook the potato or hard boil the egg has been ascer tained. This will be the time of exposure for the disinfection of clothing by this apparatus.

A good fire is important, because the steam should be gener ated abundantly and steadily As useful a heater as any is one of the large 4-burner kerosene oil stoves working under pressure on the Primus system. For the same reason the boiler should be replenished with boiling water rather than cold.

If hot water blows back through the filling pipe the chamber has been packed too tightly or the steam pipe has become blocked. Heating should be discontinued and the fault found and remedied.

A diagram of an improvised disinfector is given in Fig 21

Portable Apparatus—The steam sack disinfector This

apparatus was originally designed by Professor P S Lelean as a lousing apparatus for use on the field. In its *present form it is* suitable for disinfection of clothing The disinfecting chamber consists of a stout canvas sack, 5 feet long and 2 feet in diameter coated with a special paint to make it steam tight. At the closed end of the sack there is a flexible hose communicating with the interior and serving, when connected with the boiler to convey the steam to the interior The open end has a purse string mouth. A 10-gallon boiler and lamp are supplied with the *apparatus. The method* of *working is* Run seven gallons of water into the boiler and start the fire. (Steam should be up in fifteen minutes.) Turn the sack mouth upwards and fill it with the clothing to be *disinfected, packed loosely Draw the purse-*string mouth together Turn the sack upside down and press as much air out as possible. Hang the sack up clear of the ground. Disinfection is stated to be complete when steam has issued freely from the bottom for two minutes. When the sack disinfector forms a part of the equipment a supply of the special paint should be kept, because repeated folding of the sack cracks the surface, which should be sealed by repainting as often as necessary *A suitable paint can be made from the following*

Lamp black	56 lb
Driers	7 lb dissolved in water 5 pts.
Linseed oil	2 gals.
Soap	2 lb

Machines for the Disinfection of Goods on a Large Scale—Every large town should have an efficient machine for the disinfection by steam of articles of bedding and clothing as well as other goods. For large-scale operations such machines have the form of cylinders open at the two ends, each of which is *closed by a door One end of the* cylinder is used for the reception of the infected articles, the other end for discharging the articles after disinfection. The establishment housing the machine is designed on the same principle, one part being reserved for the reception of infected goods, the other for the despatch of the goods after disinfection, *there being no communication* between the two parts except through the disinfector The general design of such places is a walled courtyard well paved and drained, in the middle of which is the disinfecting house. The courtyard is divided into 2 parts by a wall which

runs from the boundary wall to the sides of the disinfecting house at right angles to the long axis of the disinfector The disinfecting

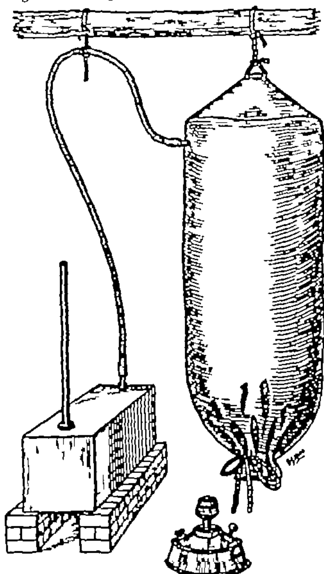


Fig 22.—Diagram of Lelean's steam sack disinfector
(*For description see text.*)

house is similarly divided by an internal wall running on the same line as the transverse wall just mentioned. It is pierced by the disinfector round which it is carried so as to form an air

tight joint. This wall may have a plate-glass window in it so as to enable the operator to see what is taking place on the other side. The working parts of the disinfector are kept on the infected side of this building and the boiler is also set up here *so that the same man may be able to look after both apparatuses* (see Fig 19).

The disinfecting chamber is fitted with a cradle on which hang bars fitted with movable hooks for hanging articles of clothing The cradle runs on wheels engaging on rails and it can be withdrawn from and replaced in the chamber by one man even when fully loaded.

The walled and paved courtyard and the disinfector house together with the necessary latrine and lavatory accommodation *for the staff represent the essentials of a disinfecting station.* If immigrants are being handled other buildings will be needed. On the infected side there may be dressing cubicles, shower baths, hot plunge baths and latrines for the use of those under going general cleansing. These communicate with the disinfected side through a door leading from the bathrooms. When the public are being treated there should be an attendant posted on *the door who will not admit anyone to the disinfected side who* has not had the specified treatment. Separate accommodation for the two sexes must be provided. On the infected side another range of dressing rooms will be necessary together with latrines, benches or waiting-room.

It will save the making of long detailed inventories, if a number of large canvas bags are provided for the packing of articles of bedding or clothing to be disinfected. The bags are provided with purse-string mouths which are drawn together by a chain which is secured by a padlock. The owner of the articles packs the bag on his premises, locks it and keeps the key The bag is then sent for disinfection at the disinfecting station after its identification number has been noted. After disinfection and drying of the contents the bag is returned to the owner intact. There can therefore be no question *of loss of articles.*

Chemical Agents of Disinfection.—These are used either in the form of gases or in solution in water

Gaseous Disinfectants Sulphur Dioxide.—Sulphur dioxide is a gas formed by the union of sulphur and oxygen. In disinfecting work it is formed by burning sulphur in the presence of air 1 lb of sulphur burned per 1 000 cubic feet = approxi

mately 1 per cent. sulphur dioxide. Though we speak of sulphur dioxide as a disinfectant, the pure gas is only feebly germicidal. When, however the gas dissolves in water an acid, sulphurous acid, is formed which is a powerful disinfectant. A moist atmosphere is enou h for the formation of sulphurous acid from sulphur dioxide and there is generally enough water vapour in the air to enable this reaction to take place. The great disadvantage of sulphur dioxide is that it has very feeble penetrating power so that it is effective only on the surface of articles. It cannot penetrate dirt, and does not dislodge it. Other disadvantages are that it bleaches coloured fabrics and tarnishes metals. For these reasons it is not much used as a disinfecting agent in Europe, but in the tropics it is useful because it destroys rats (plague), fleas (plague) lice (typhus fever and relapsing fever) and bed-bugs. By its use, therefore, we not only attack the germs of these diseases but also the animals concerned in their spread. Fumigation by sulphur should always be followed by thorough cleaning of the premises by soap and hot disinfectant solution applied with a scrubbing brush.

In practice sulphur dioxide is obtained in three ways (1) By burning sulphur candles or roll sulphur in pans in the apartments to be disinfected. (2) By liberating the liquefied gas from cylinders in which it is sold under pressure. (3) By generating the gas by burning sulphur in a special generating machine and pumping the gas into the house, the machine being worked outside. The first of these is known as fumigation by sulphur dioxide by the open method, because the gas is not generated in a special closed chamber

Sulphur for fumigation by the open method is obtainable in the form of sulphur candles, which do not resemble candles at all. A sulphur candle is a tin containing a quantity of sulphur through the middle of which runs a wick. The sulphur is lit by igniting the wick. Another form in which sulphur may be obtained is in cylinders known as roll sulphur When roll sulphur is used it should be well crushed into little bits to facilitate burning

Before fumigation is started the house should be made gas-tight after all contaminated bedding and clothing have been removed for disinfection by steam all cupboards, drawers and wardrobes opened, and all metal objects smeared with vaseline. All windows and exterior doors are then closed and made gas-tight by pasting over all joints and other apertures strips of paper

of convenient size. Old newspapers are useful for this. The pasting is done from the outside. When all external apertures have been closed, all internal doors are opened so that there may be free circulation of the gas throughout the house. A number of tubs are then distributed throughout the rooms. Each tub contains a couple of bricks on which are laid the iron pot in which the sulphur will be burned. The pots are 6 inches to 8 inches in diameter and 4 inches deep. Water is then poured into the tubs to such a depth as to come to within 1 inch of the rim of the iron pot resting on the bricks. Some of the tubs should be placed on tables, others on the floors so as to cause an even concentration of the gas in the various rooms. When all this has been arranged the inspector who has already measured the cubic capacity of the house and has the necessary quantity of crushed sulphur on the premises, distributes the sulphur in the various pots, putting about 1¼ lb in each. Then beginning with the pot farthest from the exit door he lights the sulphur in the pots, previously adding a good dose of methylated spirit to make it burn better and working always towards the door. When all are alight he comes out and the door is closed and sealed. The sealing gang should wait until burning has gone on for some time, because there is almost invariably some aperture which has been overlooked. It will be revealed by the issue of fumes and is immediately pasted over. Further scrutiny is made until all oversights have been detected and pasted over.

The house is left undisturbed for six hours, which is the time of contact necessary for a concentration of gas of between 3 and 4 per cent. At the end of this time the house is thrown open and the gas allowed to dissipate into the open air. The house is then given a thorough scrubbing with a liquid disinfectant, soap and hot water before it is allowed to be reoccupied.

When cylinders of liquid sulphur dioxide are used tubs of water are not necessary. The rooms are sprinkled with water from a watering-can and a number of empty pails are placed in the various rooms. The necessary number of containers is taken and the gas is allowed to escape by cutting off the small vent pipe at the end of the cylinder and inverting the cylinder into the pail. Again the work is begun at the most *distant* pail and proceeds in the direction of the door. When all the cylinders have been placed in position the door is sealed and the fumigation is conducted as before.

When the special generating machine is used the concentration of the gas in the house can be found out at any time by following the directions issued with each machine. A good machine of this type is manufactured by the Clayton Fire Extinguishing and Ventilating Co., Ltd. The principle on which the machine works is as follows. The house is made gas-tight as described and the machine connected up with the interior by means of flexible tubing which is branched so as to be capable of being connected up with a number of rooms All branches eventually join up with a pipe communicating with a blower which, when put into operation, sucks the air out of the rooms and passes it into a generating chamber containing burning sulphur Sulphur dioxide gas is taken up by the air which then passes through a cooler before being conducted by another system of pipes into the house. By the operation of this machine all the air in the house is made to pass repeatedly over the burning sulphur in the generator until the desired concentration of sulphur dioxide has been obtained. The machine is then stopped and the fire drawn. It is not, however disconnected from the house until the time of contact has expired because it is used to pump out the gas and pump in fresh air

In connecting up such a machine with a house the pipes for exhausting the air should be placed near the ground level and those for delivering the gas near the roof. The reason for this is that sulphur dioxide is heavier than air and tends to sink to low levels.

Formaldehyde Gas —This gas is not often used for disinfection on a large scale, but it is useful for the disinfection of single rooms, books, furs and other small and fragile articles which cannot be disinfected by steam or sulphur dioxide. Its penetrative power is poor so that it is unsuitable for the disinfection of bulky articles like mattresses and other bedding The gas does not tarnish metals nor does it bleach dyed fabrics.

The gas is evolved by the action of potassium permanganate crystals or bleaching powder on formalin. Formalin is a 40 per cent. solution of the gas in water When either of the two substances just mentioned is added to formalin, a vigorous reaction takes place accompanied by much frothing of the mixture, and formaldehyde gas is emitted. The proportions used in the British Army for fumigation are as follows 2 pints of formalin and 2 lb of bleaching powder or 1 pint of formalin and 2½ oz.

of potassium permanganate for every 1 000 cu. ft. of space. The temperature of the room must be 70° Fahrenheit (there will be little difficulty with this in most tropical places), and there should be about 70 per cent. relative humidity This can be attained by blowing steam into the room. A kettle of water boiling on a primus stove or charcoal brazier and connected through the keyhole by a length of rubber tubing fitted over the spout is all that is needed for this.

Liquid Disinfectants.—Liquid disinfectants take the form of solutions or emulsions of the disinfectant agent in water The efficacy of a liquid disinfectant depends upon (*a*) its nature, i.e whether it is deadly to bacteria or not, (*b*) the temperature at which it is used, (*c*) the length of time it is allowed to act, (*d*) the strength in which it is employed, (*e*) whether it becomes fixed by organic matter or not. There is no disinfectant which meets all these requirements so that it could be used for every type of disinfection. A substance which is a powerful disinfectant may injure the article on which it is used and a less powerful one, which has no injurious effect on the article, must be given preference. This is especially seen in the disinfectant solutions used in surgery where they must be of such a nature as not to cause inflammation of the patient's tissues or the surgeon's hands.

Not all disinfectants have the same killing power Boric acid is a very mild disinfectant, yet it has its uses in the preparation of certain surgical dressings and solutions. The acids, sulphuric and hydrochloric, are especially good disinfectants of the cholera vibrio their action in the same strengths is not nearly so effective against other bacteria.

The temperature at which the disinfectant is used has some effect on its efficacy It may be said that the hotter the solution, the more rapid and effective the action. And do not forget that time is important in disinfection. Any disinfectant needs a certain amount of time to produce its effect.

The strength in which the disinfectant is used is also important. There is for every disinfectant a certain strength below which the solution is ineffective, and in this connection the inspector should always take into account the bulk of the articles to be disinfected with a solution and allow for the diluting effect it will have on the strength of the solution used. For instance, if a disinfectant is known to kill typhoid germs in a strength of 1

part per 100 parts of water it is unlikely that infected urine would be disinfected by adding to it an equal quantity of the 1 per cent. solution, because the urine would dilute the solution to ½ per cent. To disinfect urine with a disinfectant used in a 1 per cent. solution one must therefore make the disinfectant solution to 2 per cent., so that when it is added to the urine the final solution will be of the required strength.

A good disinfectant should not be fixed by organic matter It is seldom that bacteria are voided from a patient unprotected They are generally covered with a layer of organic matter mucus most commonly which may fix certain disinfectants and prevent them from penetrating to the bacteria they are meant to kill. Mercuric chloride, for instance, forms a tough thick membrane when brought into contact with organic matter so that its penetrability is slight. Though it is a very powerful disinfectant of bacteria under laboratory conditions, its lack of penetrative power limits greatly its usefulness in practice since most of the disinfections which have to be undertaken are conducted against bacteria shielded by varying amounts of organic matter

The Standardisation of Disinfectants.—There are so many substances which are germicidal that some means of comparing their effects must be devised. The most well known effort in this direction has been made by Rideal and Walker who have devised a method whereby the disinfecting power of an unknown disinfectant may be compared with that of carbolic acid, using as the indicator a culture of typhoid bacilli in nutrient broth. The principle on which the test is based rests on the assumption that lack of growth of the bacilli in a new tube of the same broth as was used to grow them for the test experiment means that all the bacteria in the testing-tubes have been killed. The standard solution is a 1 per cent. solution of carbolic acid. The unknown disinfectant is made up in a number of dilutions, usually 4 let us say 1 1,500 1 1 600, 1 1 700 1 1,800 Twenty five little test-tubes are then arranged on a rack in five rows of five and into each a measured quantity of the culture of typhoid bacilli is put. Then to the first row an equal quantity of the carbolic acid solution is measured into each tube. The second row receives the same quantity of the unknown disinfectant in a 1 1,500 solution, the next row the same quantity of the 1 1 600 solution and so on until all the tubes have been dealt with. At the end of two and a half minutes a quantity of the

of potassium permanganate for every 1 000 cu. ft. of space. The temperature of the room must be 70° Fahrenheit (there will be little difficulty with this in most tropical places), and there should be about 70 per cent. relative humidity This can be attained by blowing steam into the room. A kettle of water boiling on a primus stove or charcoal brazier and connected through the keyhole by a length of rubber tubing fitted over the spout is all that is needed for this.

Liquid Disinfectants.—Liquid disinfectants take the form of solutions or emulsions of the disinfectant agent in water The efficacy of a liquid disinfectant depends upon (*a*) its nature, i.e whether it is deadly to bacteria or not, (*b*) the temperature at which it is used, (*c*) the length of time it is allowed to act, (*d*) the strength in which it is employed, (*e*) whether it becomes fixed by organic matter or not. There is no disinfectant which meets all these requirements so that it could be used for every type of disinfection. A substance which is a powerful disinfectant may injure the article on which it is used and a less powerful one, which has no injurious effect on the article, must be given preference. *This is especially seen in the disinfectant solutions* used in surgery where they must be of such a nature as not to cause inflammation of the patient's tissues or the surgeon's hands.

Not all disinfectants have the same killing power Boric acid is a very mild disinfectant, yet it has its uses in the preparation of certain surgical dressings and solutions. The acids, sulphuric and hydrochloric, are especially good disinfectants of the cholera vibrio their action in the same strengths is not nearly so effective against other bacteria.

The temperature at which the disinfectant is used has some effect on its efficacy It may be said that the hotter the solution, the more rapid and effective the action. And do not forget that time is important in disinfection. Any disinfectant needs a certain amount of time to produce its effect.

The strength in which the disinfectant is used is also important. There is for every disinfectant a certain strength below which the solution is ineffective, and in this connection the inspector should always take into account the bulk of the articles to be disinfected with a solution and allow for the diluting effect it will have on the strength of the solution used. For instance, if a disinfectant is known to kill typhoid germs in a strength of 1

part per 100 parts of water it is unlikely that infected urine would be disinfected by adding to it an equal quantity of the 1 per cent. solution, because the urine would dilute the solution to ½ per cent. To disinfect urine with a disinfectant used in a 1 per cent. solution one must therefore make the disinfectant solution to 2 per cent., so that when it is added to the urine the final solution will be of the required strength.

A good disinfectant should not be fixed by organic matter It is seldom that bacteria are voided from a patient unprotected. They are generally covered with a layer of organic matter mucus most commonly which may fix certain disinfectants and prevent them from penetrating to the bacteria they are meant to kill. Mercuric chloride for instance forms a tough thick membrane when brought into contact with organic matter so that its penetrability is slight. Though it is a very powerful disinfectant of bacteria under laboratory conditions its lack of penetrative power limits greatly its usefulness in practice since most of the disinfections which have to be undertaken are conducted against bacteria shielded by varying amounts of organic matter

The Standardisation of Disinfectants—There are so many substances which are germicidal that some means of comparing their effects must be devised The most well known effort in this direction has been made by Rideal and Walker who have devised a method whereby the disinfecting power of an unknown disinfectant may be compared with that of carbolic acid, using as the indicator a culture of typhoid bacilli in nutrient broth. The principle on which the test is based rests on the assumption that lack of growth of the bacilli in a new tube of the same broth as was used to grow them for the test experiment means that all the bacteria in the testing tubes have been killed. The standard solution is a 1 per cent. solution of carbolic acid. The unknown disinfectant is made up in a number of dilutions, usually 4 let us say 1 1,500 1 1 600 1 1 700 1 1,800 Twenty five little test-tubes are then arranged on a rack in five rows of five and into each a measured quantity of the culture of typhoid bacilli is put. Then to the first row an equal quantity of the carbolic acid solution is measured into each tube The second row receives the same quantity of the unknown disinfectant in a 1 1,500 solution, the next row the same quantity of the 1 1 600 solution and so on until all the tubes have been dealt with. At the end of two and a half minutes a quantity of the

mixture in the first vertical row is taken from each little tul and inoculated into a corresponding tube of fluid medium. Tw and a half minutes later the second vertical row is dealt with i the same way and so on at intervals of two and a half minut until the whole has been dealt with. We now have twenty fi tubes in five groups of five tubes, the first group containing th tubes inoculated with typhoid bacilli which had been two and half minutes in contact with a 1 per cent. solution of carbol acid and with the various dilutions of the disinfectant under tes The second group contains those which had five minutes conta with the various solutions, the third group seven and a half an so on. These tubes are incubated in the incubator for forty eight hours. They are then taken out and arranged in the former order The lowest dilutions which have killed the typho bacilli in the same time are noted and the result expressed as ratio which is known as the *carbolic acid co-efficient* or sometime as the *Rideal Walker co-efficient* This figure gives an idea a to how the unknown disinfectant compares with the standar solution of carbolic acid. The following example of the recor of an actual test will make this clear

Test Organism. *B Typhosus* in 24 hour culture in broth a 37° C. Room temperature 17° C.

Disinfectant	Strength	Time in Minutes				
		2½	5	7½	10	12½
X	1 : 1,500	x				
	1 : 1 600	x	x			
	1 1 700	x	x	x		
	1 1,800	x	x	x	x	x
Carbolic Acid	1 100	x	x			

x signifies growth in sub-culture.
The carbolic acid co-efficient is 1 600/100 or 16

You will note that the efficacy of the unknown disinfectant diminished greatly between the strengths of 1 1 700 and 1 1 800 While 1 1 700 killed the bacteria in under ten minutes 1 1 800 did not affect them after twelve and a half minutes exposure.

Disinfectants used in Solution.—Mercuric chloride corrosive sublimate. Used in a strength of 1 1 000 A very powerful disinfectant. Has limited usefulness because it does not pene

trate well if organic matter is present it stains metals, and makes stains on clothing and dressings permanent. It is an extremely poisonous substance The addition of a little hydrochloric acid to the solution improves its penetrability On account of its poisonous nature it is generally coloured with aniline blue A useful solution is Mercuric chloride ½ oz., Hydrochloric acid 1 oz., Aniline Blue 4 grains Water 3 gallons This gives a solution of nearly 1 960 This solution is useful for the occasional disinfection of the hands for crockery (wash the articles well afterward to get rid of the corrosive sublimate), glassware Unsuited for metals, linen, leather Time of contact one hour and the solution should be warm. In disinfecting the hands they should be steeped in it for one minute they are then well washed with soap and hot water using a nail brush.

Lime.—The great value of freshly slaked lime in disinfection is often overlooked It is used as milk of lime prepared by adding to fresh lime enough water to slake it. The dry powder so obtained is then made into milk of lime by adding one measure of the powder to four of water and stirring the mixture well with a stick The limewashing of walls and ceilings and allowing the wash to dry is an excellent way of disinfecting them. The addition to fæces of an equal volume of hot milk of lime will disinfect them in an hour if the fæces are well broken up in the solution while it is being gradually added It will disinfect urine It is not suitable for the disinfection of bedding or clothing but for rough work it is one of the most useful disinfectants we have

Chlorinated lime or Bleaching powder Has the same uses as lime itself It contains free chlorine which increases its bactericidal power It is used as a 2 per cent solution of the powder in water best prepared by creaming the lime with a small quantity of water and adding the concentrated solution to the amount of water necessary to yield the desired strength.

Formalin.—This is a 40 per cent. (nominal) solution of formaldehyde gas in water It is used as a 10 per cent. solution in water An excellent all round disinfectant. Sputum urine and fæces may be disinfected by one hour's contact with the 10 per cent. solution. As usual in the disinfection of fæces the fæces must be well broken up in the solution, which should be in sufficient quantity to cover them. Clothing may be immersed in it without harm and it may be sprayed on walls through a plumber's blow lamp or similar apparatus for spraying fluid

under considerable pressure. When walls are being disinfected in this way begin the spraying at the bottom of the wall and work upwards so as to make sure that the whole surface is well wetted by the disinfectant. During an epidemic of influenza or pneumonia a daily spraying of the air of rooms and apartments where numerous persons congregate is a useful preventive measure to adopt.

The Cresols.—These are substances obtained from coal tar. They form fine emulsions which may be mixed with water without deterioration. They are very powerful disinfectants, having a carbolic acid co-efficient of between 15 and 20. According to the coefficient they are used in solutions of between ½ and 2 per cent. hot and with an hour's contact. Their penetrative power is good and as a number of them contain soap they cleanse as well as disinfect. They are useful all round disinfectants and may be used for practically any articles or materials. They do not harm leather if sparingly applied in stronger solutions than are used for articles which can be immersed in them, say 5 per cent. solution.

Disinfectants Appropriate to Different Articles

Bedding. *Mattresses*. Steam.

Blankets. Steam. 10 per cent. Formalin. 2 per cent. Cresol.

Sheets. Boiling. Steam. Formalin. Cresol.

Cutlery. Boiling. Cresol. Formalin.

Knives and other handled Cutlery. Cresol. Formalin.

Clothing. Boiling (not woollen goods). Steam. Formalin. Cresol.

Urine. Corrosive sublimate in acid solution. Milk of Lime. Chlorinated Lime. Formalin. Cresol.

Faeces. Milk of Lime. Chlorinated Lime. Formalin. Cresol. Remember that faeces must be well broken up in the solution.

Leather goods. Formaldehyde Gas. Formalin. Cresol.

Crockery and Glassware. Boiling. Formalin. Cresol.

Interior of Houses and Huts. Sulphur dioxide. Formaldehyde Gas. Formalin spray. Milk of Lime. Cresol.

Outbuildings. Milk of Lime. Cresol.

Sputum. Formalin. Cresol.

Skin and Hands. Carbolic acid 1 : 20 solution. Corrosive sublimate 1 : 1 000.

Carcases. Quicklime.

Shaving-Brushes These require special treatment.

1 Place the brushes in water at a temperature of about 75° F containing bicarbonate of soda, 1 teaspoonful to the pint of water Let them steep in this for half an hour

2. Add formalin to the above so that the solution will contain 5 per cent. formalin. Allow to stand for half an hour keeping the temperature near 75 F (This can be done by keeping the vessel containing the shaving brushes in a pot of hot water which can be heated on a fire from time to time.)

3 Remove the brushes and dry them thoroughly

4 Repeat the process

The Abuse of Disinfectants

The application of a disinfectant is no substitute for cleanliness. One often sees foul urinals and latrines or collections of refuse liberally sprinkled with lime or bleaching powder when what is needed is a thorough cleansing of the apparatus or regular removal of the refuse Sprinkling a foul area will seldom deter flies from visiting it Cleanliness should come first disinfection afterwards Much money is wasted annually in the disinfection of places which really need only ordinary cleansing

CHAPTER X

HOUSING

In towns, or in countries which have been in European occupation for a certain time a Building Authority has been established by Law The Building Authority in the case of a town may be the Municipal Engineer or Architect In rural areas, the representative of the Director of Public Works and Surveys, or it may be a Board composed of officials and private persons. The Building Authority is constituted by law and is given jurisdiction over a certain area. Within its jurisdiction no building may be erected unless plans have been submitted to and approved by the Authority previous to its erection. The object in creating a Building Authority is to prevent the erection of unsuitable or badly constructed dwellings or the use of unsuitable sites. The Building Authority frames regulations specifying the standards of materials to be used of ventilation, spacing of buildings in relation to the boundaries of the land on which it is proposed to erect them and the procedure to be adopted in obtaining a permit to build. It is essential that the Building Authority should co-operate with the Sanitary Authority in this work and the best practice is for all plans to be submitted in the first place to the Sanitary Authority The Sanitary Authority then visits the proposed site considers the plan and transmits it to the Building Authority, either stating that the application may be granted, or suggesting modifications whi[illegible] made to the building before the permit is issued. T[illegible] of the building should also be made subject to a [illegible] ie Building Au[illegible] [illegible] the building has [illegible] and is fit for [illegible] [illegible]pection for [illegible] [illegible]d be [illegible] Building A[illegible] A [illegible] [illegible]d be [illegible] Sanitary [illegible] course [illegible] [illegible]orities do [illegible] In their [illegible] lly

known plan and it is the site which is the main sanitary feature

Efforts should be made to obtain the grouping of buildings of a certain class or kind in towns. One area may be allotted to shops and commercial buildings another to better-class residences another to huts.

Building Materials

The building materials in common use in the tropics are the following

Poles and Bamboos.—Advantages Availability and cheapness. *Disadvantages* Certain timbers become infested with termites which may totally destroy them so that the buildings become unsafe after a time If the bamboos are not cut at the nodes so that only the closed ends are exposed, rats and other vermin may be harboured in them.

Grass or other vegetable material used for roofing or in the construction of walls of huts *Advantages* Availability (at certain times of the year) and cheapness Good insulation against heat and cold and good ventilation *Disadvantages* Risk of fire and liability to harbour vermin.

Mud.—Used as a filling or reinforcement of grass huts. The mud is applied wet to a framework of poles and laths *Advantages* Availability and cheapness. *Disadvantages* Mud walls soon crack and harbour vermin. They require replastering at frequent intervals to keep them in good condition. A variety of the mud construction is that known as *pisé de terre* Here wooden moulds are made for the walls, and the material having been moistened to the required consistency with water is thoroughly rammed into the mould a few inches at a time. When the frame is rammed full the mixture is given some time to set after which the frame is taken apart and moved along to make another section, and so on until the first layer is complete. Beginning again at the original section the frame is arranged on top of it and another layer is added and rammed home and so on until the wall has been built. Door and window frames are incorporated in the wall during the building In the top layer large hoop iron or fencing wire is let in for fastening down the wall plates.

The materials used for pisé de terre are as follows

One-third sand one-third soil one-third ant-heap earth pulverised and sieved or two parts ant-heap earth with three parts of ashes or clinkers sieved free from fine dust. Old pieces

of wire rope and scrap or straw may be used to reinforce the mixture, but straw should be avoided because it attracts white ants (termites) If straw is incorporated in the mixture the walls should be laid on a brick or cement concrete foundation so as to prevent the access of termites to the wall from below

Walls of pisé de terre must be protected from the rain below by being placed on a raised plinth, and above by a generous overhang of the roof.

Sun-dried or Kimberley Bricks—Used with success in places where suitable materials are available. They are generally made larger than baked bricks, e.g 14 × 7″ × 7 The mixture is hand rammed into moulds and the bricks exposed to the sun to dry off. They are useful in places like Mesopotamia where the climate is dry and timber scarce. They will not hold cement and when a cement rendering has to be carried up the wall from the floor one or two courses of burnt bricks should be laid first. Weathering may be prevented by spraying the surface of a dry brick wall with limewash.

Pisé de terre and sun-dried brick outer walls may be proofed against rain to some extent by coating them with boiled linseed oil. *Advantages* Cheapness and availability good insulating properties may be made vermin proof *Disadvantages* Less durability than baked bricks.

Baked Bricks—These are generally made from moulds 9″ × 4½ × 3 in size. They are made by burning the moulded raw material (clay) in a kiln. *Advantages* They are hard, durable, impermeable to water if properly laid, easy to handle and to lay and will hold cement. *Disadvantages* Their cost places them beyond the means of most rural inhabitants of the tropics.

Cement is a mixture of lime and clay which have been burnt and reduced to a very fine powder by special rolling machinery It has the valuable property of setting hard after mixture with water and exposure to the air

Concrete is the name given to a mixture of cement, sand and gravel, broken brick, stones or clinker The size of the gravel or broken brick should not exceed 1 inch in diameter The proportions vary according to the use to which the material is to be put. For foundation walls the following mixture is suitable measured by volume cement 1 part, sand 1 part, gravel, etc., 4 parts. The materials must be mixed dry on a board and watered after mixing Concrete should be laid as soon as possible

after watering *Advantages* A clean hard vermin proof material, impervious to water and air easy to work and very durable *Disadvantages* It is costly and unless prepared skilfully it is apt to crack when used for walls and roofs.

Timber —Used a great deal in building construction in the tropics. Must be well seasoned *Advantages* Availability moderate cost and ease of handling *Disadvantages* Maintenance costs are high owing to the perishable nature of the material liability to destruction by white ants (termites) unless specially safeguarded, and dry rot

Iron —Sheets of iron, galvanised or plain, may be used in the construction of buildings, and very often for roofing *Advantages* Easily transportable durable vermin-proof and impermeable. *Disadvantages* Relatively high cost and the extremes of temperature to be found inside buildings in which iron enters into the construction of roofs and walls to a large extent.

General Sanitary Principles applied to Buildings in the Tropics

Sites —Should be elevated sheltered from extremes of sun and wind and well drained Should be located as far as possible from marshes and should be dry

Elevation provides ventilation of the site

Shelter from extremes of sun and wind makes the house more pleasant to live in.

Good drainage favours dryness and makes the occupants of the house less liable to rheumatism and diseases of the lungs (bronchitis, pneumonia and tuberculosis) which are favoured by damp Dryness prevents dry rot of the timber used in the construction of the house. Adequate drainage is facilitated by an elevated site so that water does not lie in the vicinity after rain. Mosquito breeding places are thereby reduced in numbers and the liability of the inhabitants to mosquito-borne diseases is lessened (Malaria, Dengue Filariasis and Yellow Fever) Location away from marshes also safeguards the inhabitants from mosquitoes.

Foundations may be

(*a*) earth rammed solid

(*b*) a plinth of brick, masonry or concrete

of wire rope and scrap or straw may be used to reinforce the mixture, but straw should be avoided because it attracts white ants (termites) If straw is incorporated in the mixture the walls should be laid on a brick or cement concrete foundation so as to prevent the access of termites to the wall from below

Walls of pisé de terre must be protected from the rain below by being placed on a raised plinth, and above by a generous overhang of the roof.

Sun-dried or Kimberley Bricks.—Used with success in places where suitable materials are available. They are generally made larger than baked bricks, e.g 14 × 7″ × 7″ The mixture is hand rammed into moulds and the bricks exposed to the sun to dry off They are useful in places like Mesopotamia where the climate is dry and timber scarce. They will not hold cement and when a cement rendering has to be carried up the wall from the floor one or two courses of burnt bricks should be laid first. Weathering may be prevented by spraying the surface of a dry brick wall with limewash.

Pisé de terre and sun-dried brick outer walls may be proofed against rain to some extent by coating them with boiled linseed oil. *Advantages* Cheapness and availability good insulating properties may be made vermin proof *Disadvantages* Less durability than baked bricks.

Baked Bricks.—These are generally made from moulds 9″ × 4½″ × 3 in size. They are made by burning the moulded raw material (clay) in a kiln *Advantages* They are hard, durable, impermeable to water if properly laid, easy to handle and to lay and will hold cement. *Disadvantages* Their cost places them beyond the means of most rural inhabitants of the tropics.

Cement is a mixture of lime and clay which have been burnt and reduced to a very fine powder by special rolling machinery It has the valuable property of setting hard after mixture with water and exposure to the air

Concrete is the name given to a mixture of cement, sand and gravel, broken brick, stones or clinker The size of the gravel or broken brick should not exceed 1 inch in diameter The proportions vary according to the use to which the material is to be put. For foundation walls the following mixture is suitable measured by volume cement 1 part, sand 1 part, gravel, etc., 4 parts. The materials must be mixed dry on a board and watered after mixing Concrete should be laid as soon as possible

after watering *Advantages* A clean hard vermin proof material, impervious to water and air easy to work and very durable *Disadvantages* It is costly and unless prepared skilfully it is apt to crack when used for walls and roofs.

Timber—Used a great deal in building construction in the tropics. Must be well seasoned *Advantages* Availability moderate cost and ease of handling *Disadvantages* Maintenance costs are high owing to the perishable nature of the material liability to destruction by white ants (termites) unless specially safeguarded, and dry rot.

Iron.—Sheets of iron, galvanised or plain, may be used in the construction of buildings, and very often for roofing *Advantages* Easily transportable, durable, vermin-proof and impermeable. *Disadvantages* Relatively high cost and the extremes of temperature to be found inside buildings in which iron enters into the construction of roofs and walls to a large extent.

General Sanitary Principles applied to Buildings in the Tropics

Sites—Should be elevated, sheltered from extremes of sun and wind and well drained. Should be located as far as possible from marshes and should be dry

Elevation provides ventilation of the site.

Shelter from extremes of sun and wind makes the house more pleasant to live in.

Good drainage favours dryness and makes the occupants of the house less liable to rheumatism and diseases of the lungs (bronchitis, pneumonia and tuberculosis), which are favoured by damp. Dryness prevents dry rot of the timber used in the construction of the house. Adequate drainage is facilitated by an elevated site so that water does not lie in the vicinity after rain. Mosquito breeding-places are thereby reduced in numbers and the liability of the inhabitants to mosquito-borne diseases is lessened (Malaria, Dengue, Filariasis and Fellow Fever). Location away from marshes also safeguards the inhabitants from mosquitoes.

Foundations may be

(*a*) earth rammed solid

(*b*) a plinth of brick, masonry or concrete

(c) wooden piles

(d) brick, masonry or concrete foundation walls (for wooden or iron buildings)

(e) pillars of the same materials as (d) (for wooden buildings).

When (c), (d) and (e) are *employed there is* generally a space between the floor and the surface of the ground. This space should be kept clear of rubbish (rat infestation) and should be screened off to exclude small animals such as poultry rats and mice.

(d) should be rat-proofed by laying down a concrete covering continuous with the foundation walls to make the building rat proof. Under floor ventilation (preventing dry rot in the flooring) to be provided by suitable openings in the foundation wall *screened off to prevent rats getting in* (plague, rat-bite fever infectious jaundice).

Floors are commonly of

(a) earth

(b) a mixture of earth and cow dung

(c) cement

(d) wood.

(a) The earth floor is bad because it cracks easily Ticks (relapsing fever) *infest it and when once established are impossible* to dislodge. The earth floor is difficult to keep clean (jigger fleas) and may be damp.

(b) Admixture of cow dung with the earth makes a harder floor The cow dung and earth are worked by hand with water until the mixture is of the consistency of thin gruel. It is then spread all over the floor by hand. When dry it forms a good sweet-smelling floor, but it has the same disadvantages as (a).

(c) Useful as a flooring material for huts. Is vermin-proof when well laid. Should be laid as cement concrete on a firm foundation of rammed earth or rubble. Should be at least 3 inches thick to withstand the chopping of wood on it and finished off with a rendering ½ inch thick of cement 1 sand 1 Is vermin-proof (termites, bed bugs, ticks and rats) easily swept (jiggers) and flushed (tuberculosis). Occupants in high altitudes object to it on account of its coldness on the feet.

(d) A warm, clean, but perishable material. The planks must be well seasoned so as not to shrink after laying and gape at the seams (jiggers and human fleas) Generally waxed in the tropics. Under floor ventilation necessary to prevent dry rot.

Walls.—In single-storied buildings the height of walls should bear relation to the material of which the roof is constructed. The following are suitable heights

Roof	wall height
Thatch	6–8 feet
Wood or tile	8 10 feet
Metal	12 feet

unless a wooden ceiling is interposed between the metal and the rooms, in which case the wall may be 10 feet.

Concrete and brick walls should be constructed with an interior space so as to insulate the building from heat and cold. The space should be rat proof

Damp-proof courses of asphalt or cement should be incor porated in masonry or brick walls The damp-proof course should be made at least 6 inches above the ground level and the flooring of the rooms should be laid at a higher level than the course.

Roofing may be

(*a*) thatch
(*b*) mud and lathe
(*c*) wooden shingles
(*d*) tiles
(*e*) cement concrete
(*f*) metal.

(*a*) The pitch of a thatched roof should not be less than 45 (The pitch is the angle made by the slope of the roof where it intersects a horizontal plane) The coarser the material composing the thatch, the higher the pitch. 50 to 60° is the usual. Less will not shed rain properly

(*b*) Is found only in very dry countries. It forms quite a good insulating roofing material and is generally laid flat. Many Arab houses keep the roof reserved as a latrine for the women and children. This should be prohibited, special latrines being insisted upon.

(*c*) An excellent roof where extremes of atmospheric moisture are not met with. Usually found on wooden frame buildings. Is durable when properly made and upkept.

(*d*) This roof may harbour vermin. The accompanying draw ings show how it may be made rat proof (Figs. 23 and 24).

(*e*) Expensive and as it is generally laid as a flat roof requires a good deal of maintenance to keep it water-tight.

(*f*) Unsuitable for dwelling houses, but much used on account of its portability durability cheapness and ease of construction. When no insulating material is used the walls of the house should not be less than 12 feet in height. Wooden ceilings interposed between the roof and the rooms diminish the disadvantages of the metal roof

Verandahs must be properly ventilated. Suitable width, 6 to 10 feet.

Latrines should be placed on the leeward side of premises. Pit latrines and bucket privies should be situated at least 10 to 15 feet away from the dwelling and on the opposite side of the compound from the kitchen.

Water-closets may be inside the house, but they should have independent ventilation and be properly trapped. Trapped water-closets are not a cause of mosquito nuisance so long as they are in regular use.



FIG 23 —Tiles laid in such a way as to provide rat harbourage. (Kirk, *Public Health Practice in the Tropics*.)



FIG 24 —Tiles laid to obviate rat harbourage. (Kirk, *Public Health Practice in the Tropics*.)

Drainage.—There should be a clear space round the house at least 10 feet in breadth, and no *high* vegetation should be allowed to grow upon it (ventilation, lighting and mosquitoes). Roof gutters are unsuitable in the tropics because they tend to get into disrepair sag and form breeding places for mosquitoes. A better arrangement for the disposal of rain-water is to cause the roof to project 12 to 18 inches from the wall and construct a drain in cement concrete on the ground to take the rain water falling from the roof The drain may lead into a street gutter or into an absorption pit. In places where rain-water is stored for domestic use roof gutters are of course necessary They should be inspected frequently and the water tanks sealed see water supplies. Sullage waters should not be discharged into open public drains. They should be disposed of by absorption pits or by being led into the sewerage.

Ventilation

Under Floor.—By ventilating bricks or by screened openings (vermin) on opposite sides of foundation walls (prevention of dry rot in floors).

Room.—Best attained by careful placing of windows and doors.

Huts.—Ventilation of compound huts should be independent of the action of the occupiers. Best effected by incorporating air bricks in the lower courses and by having a course containing a liberal number of air bricks near the top of the wall, high enough to prevent access by the occupants, who will try to block them up if they can. A space should be left between the wall-plate and the roof. Ridge ventilation is an excellent method of ventilating labourers' huts in countries where this type of ventilation can be installed. In countries liable to cyclones it is unsuitable because the ridge may be torn off by the wind or the rain may drive through the louvred ventilating openings. The size of ventilating openings varies with the size of the room and the number of occupants, also with the type of wall. Rooms with impermeable walls should have ventilating openings (exclusive of the thickness of the screening material) of approximately 1½ sq. in. for every square foot floor area near the floor-level. The same area of ventilating openings should be provided at a level of about 8 to 10 feet.

Back-to-back huts should not be allowed for the housing of labour unless means of through ventilation are provided. In any case they should be discouraged (tendency to the spread of droplet infections).

Lighting.—The lighting area, even in the tropics, should not be less than one-eighth the floor area.

Common Lodging-Houses and Houses let in Lodgings

There is a distinction to be observed between what are known as common lodging-houses and houses let in lodgings. Common lodging houses are houses where persons of the poorer classes are accommodated at a small cost for short periods of time and occupy a large room in common. It is the last feature which distinguishes them from houses let in lodgings in which, though a number of different persons or families may be in residence, each person or family has his own room and is not required to share it with strangers.

(*f*) Unsuitable for dwelling houses, but much used on account of its portability durability cheapness and ease of construction. When no insulating material is used the walls of the house should not be less than 12 feet in height. Wooden ceilings interposed between the roof and the rooms diminish the disadvantages of the metal roof

Verandahs must be properly ventilated. Suitable width, 6 to 10 feet.

Latrines should be placed on the leeward side of premises. Pit latrines and bucket privies should be situated at least 10 to 15 feet away from the dwelling and on the opposite side of the compound from the kitchen.

Water-closets may be inside the house, but they should have independent ventilation and be properly trapped. Trapped water-closets are not a cause of mosquito nuisance so long as they are in regular use.



FIG 23 —Tiles laid in such a way as to provide rat harbourage. (Kirk, *Public Health Practice in the Tropics*.)



FIG 24 —Tiles laid to obviate rat harbourage. (Kirk, *Public Health Practice in the Tropics*.)

Drainage —There should be a clear space round the house at least 10 feet in breadth, and no high vegetation should be allowed to grow upon it (ventilation, lighting and mosquitoes). Roof gutters are unsuitable in the tropics because they tend to get into disrepair sag and form breeding-places for mosquitoes. A better arrangement for the disposal of rain-water is to cause the roof to project 12 to 18 inches from the wall and construct a drain in cement concrete on the ground to take the rain-water falling from the roof The drain may lead into a street gutter or into an absorption pit. In places where rain-water is stored for domestic use roof gutters are of course necessary They should be inspected frequently and the water tanks sealed see water supplies. Sullage waters should not be discharged into open public drains. They should be disposed of by absorption pits or by being led into the sewerage.

Ventilation

der Floor.—By ventilating bricks or by screened openings nm) on opposite sides of foundation walls (prevention of rot in floors).

oms.—Best attained by careful placing of windows and doors.

uts.—Ventilation of compound huts should be independent e action of the occupiers. Best effected by incorporating air s in the lower courses and by having a course containing a al number of air bricks near the top of the wall, high enough revent access by the occupants who will try to block them f they can. A space should be left between the wall plate the roof. Ridge ventilation is an excellent method of ventil- g labourers huts in countries where this type of ventilation be installed. In countries liable to cyclones it is unsuitable use the ridge may be torn off by the wind or the rain may e through the louvred ventilating openings. The size of ilating openings varies with the size of the room and the ber of occupants also with the type of wall. Rooms with ermeable walls should have ventilating openings (exclusive he thickness of the screening materials of approximately q. in. for every square foot floor area near the floor level. same area of ventilating openings should be provided at a d of about 8 to 10 feet.

ack-to-back huts should not be allowed for the housing of ur unless means of through ventilation are provided. In case they should be discouraged (tendency to the spread of plet infections).

ghting.—The lighting area, even in the tropics, should not less than one-eighth the floor area.

mmon Lodging Houses and Houses let in Lodgings

There is a distinction to be observed between what are known common lodging houses and houses let in lodgings. Common lging-houses are houses where persons of the poorer classes are commodated at a small cost for short periods of time and occupy arge room in common. It is the last feature which distinguishes em from houses let in lodgings in which, though a number of fferent persons or families may be in residence, each person or mily has his own room and is not required to share it with rangers.

Common lodging-houses have a good deal of importance because they are frequented generally by the tramp class who seldom stay long in any place at a time. Their habits are liable to expose them to infection, thus making them agents in the spread of communicable disease. Moreover they generally have a profound suspicion of Authority in any shape or form, so that they do their best to avoid contact with it or to evade regulations which may entail unpleasant consequences to themselves. The occurrence of infectious disease among such people may pass unrecorded, contacts and even patients may move and be moved about freely and an outbreak of disease may be in full swing before any steps have been taken to limit it or mitigate its severity For this reason Common Lodging Houses should be entirely administered by the Local Authority A private person cannot usually provide the means to construct a suitable building and he does not have the independence of a Public Body in its administration. He must necessarily safeguard his living by catering for his customers. Their interests and those of the public are so often in conflict that the impersonal administration which only a public body can provide affords the only satisfactory solution to the problem of providing suitable accommodation for the nomadic poor

When the Local Authority is the proprietor statutory by-laws are unnecessary The Authority will ensure that the lighting and ventilation are adequate that structural requirements are met and that the rules of the superintendent of the institution will cover such matters as overcrowding, separation of the sexes and other administrative matters of importance. When, however such places are privately owned and administered, there should not only be by-laws governing their structural features but also their administration. Such by laws should contain penalties for evasion or neglect of compliance with them.

All privately owned common lodging-houses should be licensed and registered. Power should be given for the withdrawal of the licence in the event of persistent disregard of the Regulations. The owner should be required to keep posted up in a prominent position in the building a copy of whatever regulations have been enacted.

Since the rooms are occupied by a number of persons in common, strangers to one another and coming from different parts of the town or country ventilation and crowding become important.

Structural Details.—Separate accommodation should be provided for the sexes. Male children under ten years of age may be admitted with their mothers to the women's apartments.

All public rooms should have cement floors and there should be no obstructions in them which would prevent the overseer from seeing what is going on in the room from any part of it. The walls should also be of strong durable material, finished internally with a smooth surface which can be easily kept clean. Limewashing forms the most sanitary dressing for internal walls. Ventilation should be by direct communication with the open air and should be at the rate of 1 000 cu ft. per inmate per hour

Dormitories.—Overcrowding both general and local should be avoided by proper spacing of the beds. Overcrowding is dangerous because it brings persons closer together and so makes the risk of the spread of disease by droplet infection greater than it would otherwise be. There should be 6 feet between heads, the floor space to be provided should average 80 sq ft. per occupant and the cubic capacity 1 000 cu. ft per person. In reckoning the cubic capacity all space above 12 feet should be disregarded.

Beds.—The best type of bed for a common lodging-house is the hammock type. Tubular metal supports are provided on which strong canvas hammocks are lashed with cords issued for the purpose. These are issued to the occupants in the afternoon, who erect them themselves. In the morning they are handed in and are disinfected by steam under pressure before being re issued. It is only in this way that vermin-free beds can be supplied. If other bedding is issued it should also be sterilised after use. The dormitories should be cleared by a specified hour of the day Nothing should be left in them but the metal bed supports. After they have been cleared they are thoroughly scrubbed down with soap and water

Spitting in the lodging-house should be prohibited.

Latrine accommodation should be provided. One sanitary convenience for every twenty persons should be enough. The latrines must always be kept clean, and naturally separate latrines should be provided for the sexes.

The washing accommodation should be generous. Shower baths erected in galvanised metal buildings, properly drained according to circumstances, will be found useful.

The yards of the premises must be kept clean and free from rubbish. Dust bins should be provided for the reception of waste.

The occurrence of infectious disease should be notified at once to the Sanitary Authority

Khans and caravanserais should conform to the same general principles as govern common lodging houses, especially with regard to the immediate notification of the occurrence of communicable disease among the guests. Stabling for animals should be entirely separate from the part of the khan assigned to human beings. This is seldom found, the animals being hobbled in the central courtyard, round which are built the stores and guest rooms. In such places the central yard should be efficiently paved and drained. Manure and litter should be removed daily and infestation by rats and other vermin reduced to a minimum by appropriate measures.

All keepers of common lodging houses, khans and other hostelries should be obliged to keep a register of all persons accommodated. The register should contain particulars of where the person came from and his destination when he leaves. This is to enable patients or contacts to be traced in the event of communicable disease breaking out.

When houses are let in lodgings the proprietor should be obliged by law to provide a caretaker for the premises who will be responsible for the cleanliness of all parts of the premises used in common by the occupants.

A Scheme of Inspection of a Private Dwelling-house

The Inspector should proceed on a definite system of inspection as it is only by being systematic that he will be able to include all the important features at one visit. The usual object in making a routine inspection is the detection of nuisance and he should have a very good idea before he starts of what constitutes a nuisance in the public health law under which he is working Most ordinances devote several pages to the definition of Nuisance and their perusal will give him an excellent idea of what to look for The following points should be noted in a notebook at the time the inspection is being made

Address of building Owner Occupier Time and date of inspection.

General description of building e.g. dwelling house in small yard. Yard. Size (give measurements) Description (garden or bare). Paved? Well drained? Where do drains end? Condition of drains. Vegetation. Tidiness. Rubbish lying about? Mosquito nuisances? What are they? Where are they? Larvae found? (get specimens for identification) Poultry kept? How kept? in coops, or allowed to roam? Evidence of rats? Rat harbourage?

Latrines. Type? Clean? Any special features? Flies?

Bathroom. Clean?

Kitchen. Well placed or not? Flies? Any fly proof cupboards?

Dwelling house General condition. Number of rooms. Number of occupants.

Any trade process carried on on the premises?

Site. Foundations. Walls. Roof Floors. Ceilings. Doors. Windows. Rooms and passages. Evidence of overcrowding?

General cleanliness of the dwelling Evidence of vermin.

Water supply How obtained? Any storage tanks on the premises? Screened? Sullage water How disposed of?

Occupants. Occupations. State of health.

Sketch plan of premises showing nuisances found.

Note of action to be taken or advice to be given or already given.

Premises to be revisited on.

CHAPTER XI

FOOD

THE energy which is necessary to the continued existence of life on the earth is derived primarily from the sun. This energy cannot be made use of by animals in its original forms of light and heat. So far as we know the only living things which can use the sun's energy directly are the green plants. They have the valuable property of being able to use the sun's energy for building up out of the carbon dioxide of the air and the water and salts of the soil the substances such as the starches sugars, wood fibres and protoplasm which in varying proportion constitute their stems, leaves, roots and seeds. Animal life is completely dependent primarily on the vegetable kingdom for its energy It obtains its energy by the consumption of plants or their products and in the processes of digestion and assimilation it can release the solar energy in such foodstuffs and utilise it for growth, repair or work. When work is used in this sense it does not mean merely what we regard as physical work, such as digging, hauling or lifting but also the work done by the cells and tissues of the body in the different forms of activity characteristic of living structures.

The herbivorous animals can find in vegetable foodstuffs alone all the materials necessary for the growth and repair of their tissues as well as the energy for their activities. But the omnivorous animals, among which man is numbered, have lost this faculty and they must consume a certain amount of animal food in order to be able to live.

All food materials can be regarded as being composed of three great classes of chemical substances: the proteins, fats and carbo-hydrates.

The proteins are substances containing nitrogen, and as they are an essential constituent of protoplasm they are necessary for the repair and growth of the animal body Practically all natural foodstuffs contain a certain proportion of protein, but

the preparation of such raw materials for human use frequently results in the removal of the protein so that the proportion of it in the prepared food is often much less than it is in the raw material on the other hand, it may be more (cheese) The food stuffs containing the highest proportion of protein are the flesh of animals, and organs like the liver and the kidneys. The tissues concerned with reproduction are likewise rich in it, for example, eggs and fish roes. Milk contains a good deal of it, and when milk is specially prepared by the addition to it of substances which cause the milk to curdle, the clotted part consists largely of protein which may be further prepared for use as cheese.

The carbohydrates and fats are substances which do not contain nitrogen, so that they cannot be used by the omnivorous animal for increasing the bulk of its living tissues or for their repair The omnivorous animal uses these substances merely as sources of energy Carbohydrates are substances such as starch and sugar and they are found in fruits and grain and in vegetable sap They form the main source of energy of all living creatures. Familiar examples of carbohydrate foods are sugar all grain, and the various kinds of flours and meals prepared from grain tap roots and tubers such as turnips, carrots potatoes, yams and manioc.

The fats are also consumed as energy-producing foods. They may be solid, as in the fats of animal tissues, or they may be fluid as in animal or vegetable oils e.g cod-liver oil, cotton seed oil, arachis oil. Butter consists of the fat present in milk and it is found in the tropics either fresh or salted, in which case it is solid or semi-solid, or in the liquid form known as ghee or dihin, which is merely butter prepared by heating and clarification. This method of preparation prevents the fat from becoming rancid and unfit for food, though the food value is practically unaltered.

Proteins, fats and carbohydrates enter into the composition of practically every natural foodstuff. Some foods, however are not marketed in their natural state and differ a good deal from the crude materials in their chemical constitution. Thus cane juice or beet juice contains sugar (which is a carbohydrate), mineral salts, and small quantities of protein obtained from the protoplasm of the plant cells. In the course of manufacture the sugar is separated entirely from the other constituents and is marketed as a pure carbohydrate.

The energy available in a foodstuff can be measured by burning the substance under certain conditions and finding out how much heat is given off by its complete combustion, because one form which energy takes is heat. The unit of measurement is the *Calorie*, which is defined as the amount of heat required to raise the temperature of 1 kilogramme of water through 1 Centigrade. By using this method of measuring energy it has been found that carbohydrates and proteins have an energy value of 4 1 Calories per gramme while fats have an energy value of 9 3 Calories per gramme. The energy value of *fat is therefore* more than twice *that* of carbohydrates or proteins.

A living animal, even at complete rest, cannot avoid the ex penditure of energy Even if the animal itself is indulging in no form of activity its cells and tissues are at work maintaining the circulation of the blood, the repair of cells and tissues, the excretion of waste products, and the countless other activities which must go on if the animal is to continue to live. It has been found that the amount of energy used in the maintenance of life is proportional to the surface area of the animal. When man is *completely at rest in* bed *he requires energy to* the extent of approximately 1 800 Calories a day His energy requirements naturally increase according to the amount of work he does and the following table shows approximately the energy needs of a man under different conditions of activity

Activity	*Calories per 24 hours.*
Resting in bed	1 800
Sedentary life	2,500
Light work	3 000
Moderate work	3,500
Heavy work	4 000

From the foregoing table we see that a man performing moderate work requires energy equivalent to 3,500 Calories every day This energy he obtains entirely from his food. He cannot absorb any from the sun as the green plant can.

Theoretically he could obtain the energy by a diet consisting of either protein, fat, or carbohydrate, by itself, but in actual practice this cannot be done because his digestive system could not cope with the quantity of protein or fat necessary to provide such an amount of energy though it might be able for a time to obtain it from carbohydrate In order that the requisite amount of energy may be obtained with the minimum strain on the digestive organs the diet should be balanced that is to say it should contain a mixture of protein, fat and carbohydrate in certain proportions. The proportions now thought to provide proper balance are Protein 1 Fat 1 Carbohydrate 5 To obtain, therefore, a properly balanced diet furnishing energy equivalent to 3,500 Calories which is what he needs if he is doing moderate work, a man should consume a diet containing the equivalent of 500 Calories in the form of protein, 500 Calories in the form of fat and 2,500 Calories in the form of carbohydrate. According to the energy value of these substances which we have noted above, his diet would need to consist of approximately 125 grammes protein, 55 5 grammes fat and 625 grammes carbohydrate.

Few of the foods we eat, with the exception of sugar consist of only protein, fat or carbohydrate. Protein foods such as meat contain also fat plant seeds, though mainly carbohydrate, contain also proteins and fats. In drawing up properly balanced dietaries it is therefore essential to know the approximate chemical constitution of the various common foodstuffs. Much work has been done on this subject and tables are now published in books on dietetics giving the required information. The following table, compiled from several sources, shows the composition and energy equivalent of a number of tropical food stuffs.

The table on page 176, mainly after W H. Wilson, shows the percentage composition and food value of various foodstuffs commonly available in the tropics.

From tables such as this, *existing* dietaries may be checked or new ones devised. It should be noted that the percentage of water and salts in the various foodstuffs have been omitted. These substances are of very great importance in a dietary but as they do not form a source of energy they have been omitted from the table.

We have seen that a properly balanced diet requires one

PERCENTAGE COMPOSITION AND FOOD VALUE OF VARIOUS FOOD-STUFFS COMMONLY AVAILABLE IN THE TROPICS

Food Material.	Available Protein per cent.	Fat available per cent.	Carbohydrate available per cent.	Calories per 100 grammes.
Native Bread, wheaten	5 0	1 0	47 5	225
" millet	3 4	1 5	45 0	212
Fresh Butter	1 0	85 0	0 5	795
Ghee, Dihin, lemma (melted butter)	—	93 0	—	865
Eggs 1 = 40 gm.	12 5	10 5	—	150
Cow's milk	3 4	4 0	5 0	72
Buffalo milk	4 0	7 9	4 8	109
Lentils	19 3	2 0	59 8	324
Peas	14 3	1 8	55 0	304
Rice	6 5	0 4	76 0	330
Millet	6 6	4 2	68 0	344
Maize	6 7	4 7	72 0	357
Sugar	—	—	100	410
Dried Dates	1 9	2 5	75 0	339
" Figs	4 4	0 9	62 0	282
Yams	1 8	0 5	15 0	75
Bananas	0 6	0 4	14 2	65 0
Beef (Flank)	8 76	54 1	—	539
Mutton (Loin)	9 47	56 57	—	564 9
Liver (Ox)	19 9	3 2	4 4	129 4
Chocolate	4 8	31 1	59 9	554 4

seventh in the form of protein. A considerable quantity of this protein should be animal and not vegetable protein because the vegetable proteins lack certain constituents which are essential to most animal life. The animal protein may be obtained from flesh, fowl or fish milk, eggs or cheese.

Accessory Food Substances, or Vitamins

But there is more in proper dieting than the mere supply of energy and of material to replace the wastage of the tissues. When animals are fed upon specially prepared artificial diets which are fully adequate in their food constituents, according to chemical standards, they die after showing signs of serious nutritional disturbance. The only way in which such diets can be made nutritious is by the addition of small quantities of natural foodstuffs. It is therefore thought that natural foodstuffs contain some substance or substances which enable the body to make full use of the food, which it cannot do if they are

absent. These substances have come to be known as *vitamins*.

As the vitamins were studied the discovery was made that a number of disease of hitherto unknown origin such as rickets, scurvy scurvy-rickets, pellagra and beri beri as well as a number of obscure complaints occurring among inmates of institutions, were due to the absence from the dietary of certain vitamins and that outbreaks of such diseases might be prevented by including in the dietary substances found to be rich in the vitamin concerned. The common vitamins are the following

Vitamin A—Soluble in fats. Occurs in the oils obtained from the livers of certain fish, e.g cod-liver oil and halibut-liver oil. Fresh cream and butter contain it in abundance. It is present in the yolk of eggs and in green vegetables. It is absent from vegetable oils such as margarine, cotton-seed oil etc.

Vitamin A influences growth and increases the resistance of the body to disease.

Vitamin D The source of vitamin D is practically the same as A. Deprivation of vitamin D gives rise to disorders in the growth of the bones and results in rickets.

Vitamin B complex—The substances comprised in this complex are soluble in water The important constituents of it are Vitamin B1 (Thiamin chloride) known as the antineuritic vitamin. It regulates the nutrition of nerves and blood vessels. When this vitamin is deficient in the diet beri beri results Vitamin B2 (nicotinic acid) or the pellagra preventing vitamin. Deprivation of this vitamin is thought to be the cause of pallegra. Vitamin G (riboflavin) regulates growth.

The Vitamin B complex is found in fresh milk, yeast, bran, eggs, and in germinating peas and lentils. The milling and polishing of rice removes the part of the grain most rich in the vitamin B complex and if persons whose diet consists almost exclusively of rice eat only the highly polished variety and do not consume enough of the other foodstuffs rich in the vitamin they may develop the disease known as beri beri.

Vitamin C is also soluble in water This is the vitamin which prevents scurvy and deprivation of it causes scurvy It is found in oranges and lemons, fresh milk, fresh meat, fresh green vegetables and germinating pulses. It is destroyed by prolonged heating so that when the only source of this vitamin in the diet

is green vegetables these should not be cooked for longer than is necessary to make them palatable (about fifteen minutes in boiling water).

The Preparation of Germinating Pulses—Pulses are peas, beans, or lentils. When they germinate they are a rich source of vitamin C, the anti-scorbutic vitamin. Germinated pulses may be used in the diet when other anti scorbutics such as fresh meat, vegetables or fruit are not available and where no lemon juice can be obtained.

Method.—The peas, beans or lentils *must not* be milled. They must have the seed coat intact or they will not germinate. The pulses are placed in a clean sack which is large enough to allow the seeds to swell to about three times their original size. The sack of seeds is soaked in clean water for six to twelve hours. The seeds are then removed from the water and are spread on trays having perforated bottoms so as to allow the air to circulate freely among the seeds. A damp piece of clean sacking is laid over the seeds to keep them moist and the trays are laid aside in a warm place to cause the seeds to germinate. The time required for germination varies with the temperature, but it is not less than twelve hours. At 60° F it is about forty-eight hours at 80 to 90° F it is twelve to twenty four hours. The seeds must be kept moist or they will not grow When the small rootlets have grown the pulses are ready for cooking They must not be allowed to become dry after germination, or their anti-scorbutic properties will disappear They should not be cooked longer than is necessary fifteen minutes boiling is as much as can be given to them without impairing their anti-scorbutic qualities.

Salts and Water

If an animal is fed upon an artificial diet comprising pure proteins, fats, carbohydrates and water in the proportions necessary for a well balanced diet it soon begins to sicken and eventually dies. This can be prevented by the addition to the diet of mineral salts which are thus seen to be essential to the life of the living animal. Important sources of salts in man's dietary are leafy vegetables and fruit.

The importance of water to living creatures is so well known as scarcely to require reference here at all.

Food Inspection

The inspector will find that many foodstuffs which would not be tolerated in European shops and markets because of their appearance, smell, or source, find a body of appreciative consumers in tropical or far-eastern countries. He will soon come to the conclusion that what is one man's meat is another man's poison, and will probably despair of finding any means of judging whether many indigenous foodstuffs and condiments are fit for human consumption or not.

But there are certain foodstuffs whose quality he can control These are tinned foods milk and milk products and the flesh of animals exposed for sale. A few notes about these are given hereunder

Legislation.—The inspector cannot take any action unless he has the power given to him either by the enactment by the Government of Ordinances and Regulations or by Administrative orders and rules, according to the type of Government in the country in which he is serving Regulations governing the quality of foodstuffs generally prescribe that all food offered for sale shall be fresh, clean and wholesome, and shall not contain adulterants or injurious substances. The amount of preservative allowable in certain kinds of food is generally laid down and provisions are made for penalising those who are convicted of contravening the provisions of the law Since the subject of the seizure or condemnation of food on the ground of unwholesomeness may mean the appearance of the inspector in Court, where he is generally the prosecutor it is of great importance that when regulations exist specifying the procedure to be followed in the taking of samples for analysis, or in condemning unsound food, the inspector should follow them scrupulously so as to avoid his case being dismissed by the magistrate upon a technicality Further reference will be made to this in connection with milk.

Methods of Preserving Foodstuffs

The deterioration of food takes place mostly through the action of putrefactive bacteria which, under favourable conditions, swarm through the foodstuff and break up its constituents into repulsive or poisonous products.

The border line between putrefaction and gaminess is by no means definite and some foodstuffs are habitually con-

sumed in a very "gamey" state, e.g. pheasants, grouse, partridges and other small game.

The preservation of food consists of submitting it to certain processes which either destroy or inhibit the action of the putrefactive bacteria, i.e. the bacteria which cause organic matter to putrefy.

Since bacteria cause the deterioration of foodstuffs it is clear that the cleaner the food is when submitted to the preservative process the better chance it has of keeping edible.

There are several things to be kept in mind in considering the preservation of food:

(a) prevention of loss of nutritive value.
(b) preservation of wholesomeness.
(c) prevention of the development of injurious properties.

1. *Desiccation or Drying.*—Used for a very long time. May be combined with other methods such as salting or smoking. The nutritive value of the food is preserved, but the flavour is generally altered. Examples of desiccated food are: biltong (dried or jerked beef) i.e. strips of beef cut thin and hung in the open air exposed to the sun; smoked fish; dried shrimps; currants; raisins; dried apple rings. Dried foods resist decomposition so long as they are kept dry.

Modern drying machinery has enabled us to extend the list by including such substances as milk and eggs.

2. *Salting or Pickling.*—Salting is the preservation of a foodstuff by treating it with dry salt. Pickling is the preservation of a foodstuff by immersing it in a strong salt solution (brine) containing sometimes other substances such as vinegar, sugar or condiments.

The pickle should contain not less than 18 per cent. of salt. The action of the pickle is to prevent the growth of putrefactive bacteria. It preserves meats and vegetables for long periods and gives a distinctive flavour and appearance to them.

Trichinæ and cysticerci die after three weeks' immersion in brine.

3. *Boiling in Sugar* ("preserving").—Used in fruit preserving, resulting in jams, jellies, and marmalades. The boiling kills the bacteria and the syrup prevents the growth of others which may gain access to the containers after the boiling has been done.

4. *Application of Cold.*—Two degrees of this process are recognised: "Chilling," when the temperature is kept at about

the freezing point of water and Freezing when the temperature is between -15 C. and $-7°$ C. Foods preserved by chilling are not common in the tropics except in towns and cities with a sufficiently large population and means of transport to enable the establishment of cold stores.

Canning—The process of canning foodstuffs is practically that of sterilising them in special containers by means of heat and sealing the container while it is still too hot to allow of contamination from the air to enter

Properly canned and stored foodstuffs will last for years, and the method is becoming increasingly applied as a means of storing food, or of providing supplementary items for the dietary in places where the choice of foods is limited.

Elaborate machinery is now made for the canning of foodstuffs.

Since the tins in which the food is processed are sealed while they are still hot and full of steam the cooling of the contents and the condensation of the steam as water inside the container make a vacuum which is enough to suck in the ends of the tins. A sound tin therefore has concave ends, or at any rate, ends which do not bulge. The occurrence of decomposition in the contents of the tins during storage or transport generally results in gas being evolved under enough pressure to make the ends of the tin bulge. Tins with bulging ends should therefore be selected for further examination. Traders know this by now and the unscrupulous may puncture the tin to allow the gas to escape, in which case the ends will revert to their normal shape and the tin appear sound. The inspector should therefore note in any batch how many solder-marks there are in each tin there may be one or two. Any tins which have more than the average number may be suspected of having been tampered with and should be removed for further examination. Rust holes may admit putrefactive bacteria from the outside and since there is no bulging to reveal the gaseous decomposition which may have taken place, such tins are apt to be undetected unless carefully looked for In this connection the inspector should remember that old tins are frequently given new labels so that if there is any discrepancy between the apparent age of the tin and that of the label the label should be removed to see if it does not conceal serious rusting.

In sampling a consignment of tinned foodstuffs it is customary to open 10 per cent. of the cases. In smaller consignments the

percentage must necessarily be higher Bulged cases must always be opened. Stained cases, where the stain comes from inside the case, should also be opened. The stain is probably due to a tin having been pierced by a nail in the packing of the case.

Chemical Preservatives —With the development of canning and cold storage, both of which methods of preserving foodstuffs are efficient and cover a very wide range, the use of chemical preservatives should gradually diminish. The few survivors are mentioned here

Borax and boric acid. Occasionally used in the preservation of milk or cream.

Sodium nitrate (saltpetre). *Used to give a* red *colour to* meat.

Sulphur dioxide and sulphites. Used in the preservation of fruit juices.

Benzoic acid (Benzoate of sodium). Used as a preservative for catsup

Meat Inspection

The canning industry is now so highly organised that canned foods are of little danger provided that they come from sound tins. In the tropics it is the fresh meat that is likely to be dangerous because the people are not nearly so fastidious where meat is concerned as are the inhabitants of European countries.

The important diseases which may make the meat of infected animals unfit for human food may be classified as those common to animals and man, and those restricted to animals. They are as follows

Common to animals and man

- Beef and pork measles (beef and pork the cysticercus stage of human tapeworm).
- *Trichina spiralis* (pork).
- Foot and mouth disease (beef, mutton, pork).
- Actinomycosis (beef).
- Anthrax (beef, mutton, sometimes pork)
- Tuberculosis (beef, pork and fowls).

Restricted to animals but rendering *the flesh unfit* for human food

- Swine cholera (pork).
- Nagana (cattle)
- Pleuro-pneumonia (cattle).

Control of Meat

The subject of meat inspection cannot be learnt from books alone. It can only be learnt by practical experience. If the inspector has not already taken out a course of instruction he should lose no opportunity of obtaining experience either from some qualified inspector his medical officer of health or a veterinary officer Here will be given only a few notes serving merely as an aid to memory of the subjects most likely to cause difficulty

COMPARISON OF COMMONLY CONSUMED ORGANS OF CERTAIN FOOD ANIMALS AND THE HORSE

Organ.	Cattle.	Horses.	Sheep.	Swine.
Stomach	4-chambered (a) rumen (b) reticulum, (c) omasum, (d) abomasum.	Single-chambered	4-chambered	Single-Chambered
Lungs	Trachea with about 50 cartilaginous rings and ends in 3 large bronchi. Right lung 3–4 lobes. Left 2–3 lobes.	Left, 2 lobes. Right, 3 lobes.	Trachea with 48–55 rings. Ends in 3 main branches Right lung, 4 or 5 lobes. Left, 2–3 lobes.	Trachea with 32 cartilaginous rings. Ends in 2 main branches. Right lung, 3–4 lobes. Left lung. 2–3 lobes.
Liver	Weight about 12 lb. Lobes not separate, 2-lobed. Gall-bladder present.	Weight about 11 lb. 3-lobed. Gall bladder absent.	Weight 1–1½ lb. 2-lobed. Gall-bladder present	Weight 3–4 lb Divided into 4 lobes. Gall bladder present.
Kidneys	Numerous lobes. Weight, 10 oz. to 12 oz.	Right kidney heart shaped. Left kidney bean shaped. Not lobed. Right kidney 27 oz. Left kidney 25.	Not lobed Weight, 2–3 oz.	Not lobed Weight, 3–6 oz.

The Lymphatic System of Food Animals

In Chapter II a brief description of the lymphatic system of man was given. The lymphatic system of food animals follows the same general plan.

The lymphatic vessels draining a region of the body sooner or later empty into a lymphatic gland, which acts as a kind of living strainer for the lymph. The lymph gland can kill and digest micro-organisms brought to it by the lymph because it consists of a sponge-like mass of tissue containing cells which devour

other cells and bacteria. They are identical with certain varieties of the white corpuscles of the blood. Such glands are known as the *regional lymph glands* and the inspector should be familiar with their position in the carcass because if there is damage to or infection of any part of the body it may be revealed by a swelling and congestion of the regional lymph gland. Moreover the

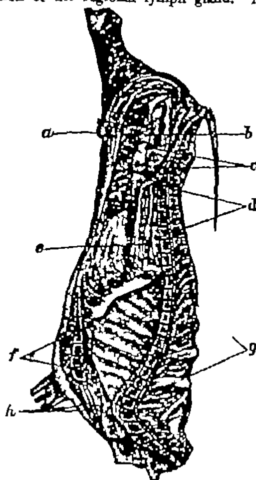


FIG 25.—Section of carcass of ox showing position of the important lymph glands.
(*Ostertag' Meat Inspection.*)

a, superficial inguinal, or in female supramammary lymphatic glands; *b*, iliac glands; pelvic glands; *d*, lumbar glands; *c*, renal glands; *f*, suprasternal glands; *g*, subdorsal or dorsocostal lymph glands of upper thorax; *h*, lower cervical or prepectoral glands.

bacillus of tuberculosis is very often caught by these glands, causing them to swell and sometimes to disintegrate and thus give evidence of the disease when other infected parts of the body may appear to be quite healthy When a swollen gland is

seen to be filled with the cheesy product of tuberculosis it is said to be *caseated* and the process of tubercular destruction of this kind is known as *caseation*

The majority of normal lymphatic glands are small spherical or kidney-shaped structures sometimes embedded deep in the tissues and sometimes near the surface. They vary in size from the size of a pea to the size of a cherry The colour of the cut surface varies from nearly pure white to greyish or brownish (remember they contain large numbers of *white* blood corpuscles) They are fairly firm in consistence.

The following description of the regional glands is abstracted from Leighton

Lymphatic Glands of the Head, Trunk and Extremities

1 Submaxillary Lymphatic Glands (Fig 27 *k*).
 Situation Just underneath the lower jaw about two-thirds along from the chin.
 Area drained The lower half of the head.
2. Upper Cervical Lymphatic Glands (Fig 27 *i*).
 Situation On either side of the posterior wall of the pharynx and larynx near the thyroid gland.
 Area drained Practically the whole of the head, including tributaries from the submaxillary lymphatics.
 This group also includes the retropharyngeal glands.
 Very important from the point of view of Tuberculosis.
3 Lower Cervical Glands (Fig. 25 *h* Fig. 27 *h*).
 Situation On the interior wall of the trachea.
 Area drained Middle and upper cervical glands and prescapular gland.
4 The Prescapular Glands (Fig. 26 *c*).
 Situation Exactly in front of the shoulder-joint.
 Area drained Neck, shoulder arm and forearm. They are important in estimating the condition of the fore quarters of the body
 In cattle and hogs the prescapular glands are single.
 In horses they form a cluster
4 The Precrural Glands (Fig 26 *b* Fig 27 *d*).
 Situation See Figures 26 and 27
 Area drained Anterior part of thigh and outer part of the abdominal walls.
 The precrural glands drain into the lumbar glands.

6 Superficial Inguinal Glands (Fig 25 *a* Fig 27 *c*).
Situation In male animals at neck of scrotum. In female animals above and behind the udder
Area drained External sexual organs, lower abdominal wall, and middle portion of the thigh. They drain into the thoracic duct.

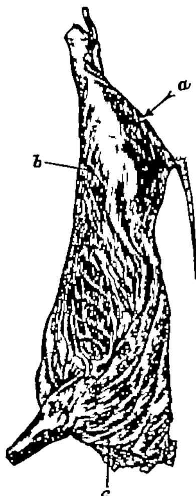


FIG. 26 —Carcass of ox showing position of important lymphatic glands
(*Ostertag's Meat Inspection.*)
a, popliteal lymphatic glands; *b*, precrural glands prescapular glands.

7 Popliteal Glands (Fig 26, *a* Fig 27 *b*).
Situation See diagram.
Area drained All the posterior extremity of the body

Lymph Glands of Thorax Abdomen and Pelvis

A. Glands in the Carcass.

The thoracic glands. Upper and lower (Fig 25 *g* Fig 25 *f*).

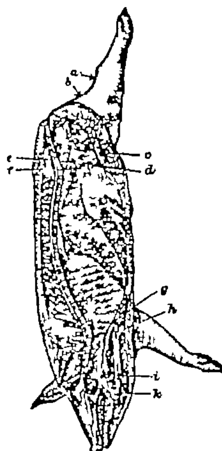


Fig. 27—Carcass of hog showing position of lymphatic glands

(*Ostertag Meat Inspection.*)

a, glands of the upper half of the back *b* popliteal glands ; *c*, superficial inguinal or supramammary glands ; *d*, precrural glands ; *e*, *f* internal iliac glands ; *g* glands of lower thoracic wall ; *h*, lower cervical or prepectoral glands *i*, upper cervical glands *k* sub-maxillary glands.

Situation Upper in the intercostal spaces along the vertebral column lower close to the sternum between the cartilages of the ribs.

the heart and wash out the blood (this can be done by the slaughterer). Examine the heart, especially for cysts in the muscles, cut through the liver examine for flukes and tuberculosis.

Cut down on the glands of the lungs and examine them.

Feel the lungs thoroughly by *squeezing through the hands to* detect lumps. Then cut across each lung and examine the cut surface for tuberculosis.

If all correct, stamp as before. If disease found, condemn the diseased organ.

Examine the Carcass.—Outside for bruises, contusions, abscesses. Inside.—Examine the cavities for inflammation or tuberculosis. Look carefully at kidney fat. Pick up diaphragm and examine carefully both sides for tuberculosis.

If all organs are healthy and the beef looks good the carcass may be passed.

If tuberculosis is present in an organ the lymphatic glands of the carcass must be systematically examined to see if any other region of the body is affected.

Bleeding —All slaughtering processes in the tropics should be directed to obtaining the maximum amount of bleeding from the animal because the keeping power of the meat depends mostly upon the amount of blood removed from the carcass at death. The less blood there is in the carcass the better will the meat keep. The following description applies only to beef which has been well bled.

Characteristics of good Beef Mutton and Pork

Beef.—Colour uniform, faintly marbled with fat. Faint sweetish characteristic odour Firm in texture and does not pit or crackle on pressure. Not unduly moist. Colour varies from light red to dark red according to sex of animal darkest in bulls, but the essential point is that the colour should be uniform throughout.

Veal.—The meat of calves. Paler than beef. If the calf has been milk fed the meat is almost white. The fat *is gelatinous* and the flesh softer than that of oxen.

Mutton.—Colour light red, consistence firm, fine grained and having an abundance of white hard fat between the muscles. Distinct odour

Pork.—Colour pale red or pink. *Flesh less firm than any of*

the preceding Fibres fine, consistence soft and the meat practically odourless.

Freezing makes meat paler and moister

Unsound Meat.—The acid reaction of sound meat changes to alkaline. The meat loses colour becomes flabby and moist. The odour of putrefaction may be smelt by sticking a clean metal skewer into the joint near a bone and smelling it when it is withdrawn.

Some Parasites rendering a Carcass or Portions of it Unfit for Human Food

1 *Cysticercus cellulosæ*—A stage in the history of the human tapeworm. Affects beef and pork, infected flesh being known as measly flesh. Infected meat or pork is studded with tiny greyish transparent bodies a little smaller than a pea. Found between the muscle fibres. Muscles of head, neck and shoulders most frequently affected. In oxen the heart muscle may contain them. The flesh is pale and flabby An infected carcass should be condemned unless it can be kept in cold storage at a temperature of under 20° F for at least three weeks. Storage for this time kills the cysticerci.

2. *Trichina spiralis.*—Affects pigs and may be contracted by man through eating imperfectly cooked infected pork. The adult worms, which are nematodes, live in the intestines. The females lay large numbers of eggs which hatch in the intestines into tiny larvæ which gain access to the muscles and there come to rest inside little pale transparent capsules. The muscles most often affected are those of the diaphragm, larynx, tongue and abdomen. The affected meat may be recognised by the naked eye because it has the appearance of containing very minute grains of white pepper in its substance. The diagnosis is confirmed by the microscopical examination of the suspected muscle. A small piece is taken and is teased out in saline solution on a glass slide. A cover glass is applied to the preparation and pressed firmly down so as to flatten the fibres. The preparation is then examined under the microscope when the larvæ may be seen coiled up inside the cysts.

Infected carcasses should be condemned.

3 *Lung Worms.*—Parasitic round worms affecting the lungs of cattle, sheep and swine. They cause bronchitis or pneumonia. Affected lungs should be destroyed and the carcass examined

carefully for dropsical effusion. If this is found the carcass and organs should also be seized. If the damage is limited to the lungs these *only* should be seized.

4 *Liver Flukes*—Parasitic flat worms (trematodes) infecting the gall bladder and bile ducts of cattle, sheep swine and goats. Healthy portions of the liver may be passed infected portions cut out and seized.

5 *Hydatids.*—The cystic larval stage of the dog tapeworm *Taenia echinococcus*. In the tissues of the infected animal the cysts appear as white-walled circular bladder like structures varying in size from a pea to that of a large orange or grape fruit. They are full of clear fluid in which are floating large numbers of daughter cysts of varying size.

Affected parts of the carcass should be seized and destroyed. Healthy parts may be released.

The following conditions make it necessary to condemn the *whole carcass and all the organs*

Actinomycosis, generalised Anaemia (if pronounced) Anthrax Blackleg Extensive and severe Bruising *Cysticercus bovis Cysticercus cellulosae* (pork), if generalised Decomposition, general Dropsy general Emaciation associated with disease Erysipelas acute swine Fever acute Foot and mouth disease Glanders Immaturity Jaundice Lymphadenitis, caseous malignant Catarrhal Fever Malignant Neoplasms (cancerous tumours) unless localised to one organ Mammitis (inflammation of the udder), acute septic Melanosis, generalised Metritis, acute septic Uraemia, or carcasses having a urinous odour Pericarditis, septic Pneumonia, gangrenous, Pyaemia Rickets with malnutrition Sarcocysts Septicaemia Swine fever Tetanus Trichinosis Tumours, multiple in beef.

Action to be taken with regard to Tuberculosis

Organs —An organ showing tuberculosis in any part should be seized.

Head.—The head, including the tongue, should be seized, if any of the lymphatic glands of the head is affected.

Carcass —The entire carcass and organs should be seized if there is evidence of generalised tuberculosis. Otherwise only the affected region or organ and its regional lymph glands should be seized.

In all difficult cases call in the Medical Officer of Health or a veterinary officer *is possible* if not, err on the side of safety

CHAPTER XII

FOOD (*continued*)

Abattoirs

An abattoir is an establishment where food animals are slaughtered and their carcasses prepared for sale. If the abattoir is not administered on sanitary lines it may become a serious nuisance. Diseased or inferior meat may be offered to the public the premises may be the happy hunting-ground of dogs, jackals, rats and flies, all of which are important transmitters of disease.

The whole process of the preparation of meat for sale should be under the direct supervision of the Sanitary Authority For this reason all the meat consumed in a town should be slaughtered in one abattoir rather than in a number of them. This points to the enactment of legislation giving the Municipal Council or other governing body of the town power (*a*) to erect and conduct a public abattoir (*b*) to enact by laws or regulations for the proper administration of the establishment, (*c*) to make certain charges for the accommodation and services rendered, and (*d*) to close down any privately owned abattoirs within municipal limits. The evasion of the last provision can be prevented by enacting also that all meat sold to the public whether in public markets or butchers shops shall be clearly marked with the abattoir meat stamp as a guarantee that it has been inspected and passed fit for human consumption.

In large establishments the soundness of the meat and the cleanliness of the methods of preparation are ensured by the appointment of specially qualified meat inspectors. In the smaller this work is done by the Sanitary Inspector working in conjunction with the Medical Officer of Health. Since the whole process of slaughter and preparation of the meat should be conducted under the direct supervision of an officer who has other important duties to perform, it is necessary to limit the hours of slaughtering to a definite period of the day In most parts of the tropics

slaughtering is generally carried out between the hours of five and seven o clock in the morning

On account of the noise made by the animals and the tendency for an abattoir to attract rats, an abattoir should be built on the outskirts of the town and at least 100 yards from the nearest house. All the buildings and lairs should lie inside a walled compound. The lairage, offal treatment rooms, midden and destructor should be situated to the leeward of the other buildings so as to prevent hanging carcasses from acquiring undesirable flavours. It is an advantage when stock is brought to the town by rail to locate the abattoir at a convenient railway siding to prevent the animals from being driven through the town.

Lairage.—Lairage is the name given to the accommodation provided for the animals. It is here that the first inspection of the animal should be made and the pens, if inside a building, must be well lit. Good ventilation is also necessary The pens are best constructed of tubular steel set into a properly drained concrete floor If brick is used for the flooring it should consist of specially hardened bricks. Watering troughs should be provided which should be of iron and of such a shape as to be easily cleaned. The interior walls should be kept white by frequent limewashing.

A separate lair should be provided at some distance from the main buildings to serve as a quarantine lair or for keeping an animal under observation for a short time.

Separate lairs are provided for sheep, pigs and oxen. Goats may be laired with sheep.

Small animals are generally driven straight to the slaughtering hall from the lair but oxen may have stalls provided for them just outside the slaughtering hall. The stalls are convenient places in which to handle the animals before slaughter

The Slaughtering Hall.—The hygienic points to be observed with regard to slaughtering halls are as follows

Floors The floors should be hard, non-slip and impervious to water They must be kept in good repair They should be graded to drain into a main drain.

Walls The lower part of the walls should meet the floor on a curve instead of at an angle. This is to avoid corners where dirt may lodge. For the first 6 feet the wall should be faced with a smooth impervious material if it does not consist of white porcelain-enamelled bricks. Above this height the wall should be

kept limewashed so as to provide as much light as possible Window space must be generous and adequate ventilation ensured both by windows and roof ridge ventilators.

In small abattoirs dressing of the carcass is carried out in the slaughtering hall.

Lifting apparatus is necessary Metal chains or wire ropes should be used in preference to rope of vegetable fibre which quickly becomes filthy and cannot possibly be kept clean. There should also be along the hall, or in each cubicle if slaughtering is

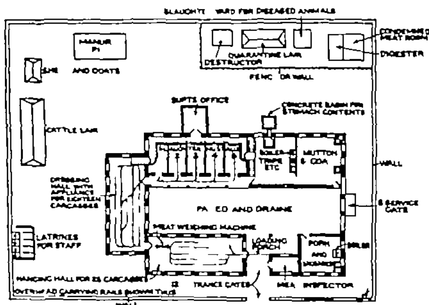


FIG. 28.—Lay-out of a small municipal abattoir Surface drainage not shown.

done in cubicles, at a convenient height, a stout metal rail fitted with hooks for hanging the parts of the carcass removed at this stage, e.g. head, heart, lungs.

Meat marking apparatus is required. This is best obtained in the form of a self inking roller stamp on which different numbers may be inserted to denote the day on which the meat was inspected and to prevent forgery This stamp should be handled only by the meat inspector and should be kept under lock and key when not in use. It is important that every impression made by the stamp should be clearly legible.

The inspector should keep on the premises a good supply of sharp knives. If he should happen to cut into diseased meat or glands he should lay aside the contaminated knife for disinfection and continue with a clean knife. The knives and cleavers used by the butcher on a diseased animal should also be removed at once for disinfection.

The dressing of carcasses should not be done on the ground. The carcass should be gradually raised during flaying so that by the time the skin has been removed it is hanging well clear of the ground. It should be high enough to make room for the tray into which the abdominal organs will be received for inspection.

The above observations relate to the slaughtering hall for large animals. The same principles of construction and operation apply equally to the halls in which smaller animals are slaughtered. In the pig slaughtering hall steam heated tanks are necessary for scalding and scraping the carcasses.

After the day's work has been done the floors and walls are flushed down with a hose and brushed so as to leave the place clean for the following day

Spitting should be prohibited on all abattoir premises.

When there is a mixed community the abattoir will have to be designed to avoid offence to the susceptibilities of different sections. Oxen cannot be slaughtered in a hall used for the preparation of meat (goat and mutton) for Hindus or pigs in a Mohammedan one. *In such circumstances separate apartments* must be provided on the premises.

Most slaughtering in the tropics is done by bleeding the animal to death without preliminary stunning The process is probably not nearly so inhumane as it looks, since, with the severance of both carotid arteries, unconsciousness must very quickly supervene. This method of slaughtering improves the keeping qualities of the meat.

The Hanging Room is the room in which the dressed carcasses, after inspection and stamping, hang for the flesh to set pending delivery to the butcher In big cities the hanging room is generally supplemented by an artificially cooled chilling room or even a cold store. In smaller places this is not necessary because the slaughtering is fairly closely adjusted to the demand and the whole of the meat sold on the same day as killing takes place.

Oxen and pigs should be hung in separate rooms where there are Mohammedans, Jews and Hindus.

An Offal Room is necessary for the preparation of tripe and for gut-scraping Tanks with steam laid on are the best form of tripe boiler The steam can be used also to heat the digester and to supply other hot water to the establishment. The tanks should be of glazed earthenware or enamelled iron. Similar tanks will be needed for keeping the dressed tripe under water

The Condemned Meat Room should be entirely separate from the other buildings and should be kept locked. Adjoining it and communicating with it may be a room containing a digester which is really a kind of steam disinfector working under pressure. The digester is used for the sterilisation of condemned meat and for the extraction of grease from it. The condemned meat room should be big enough to take a whole carcass it must be fly proof and at the same time well ventilated. All the fittings should be metal, preferably highly polished stainless steel, and all internal surfaces hard smooth and impervious to water On account of the fact that this room houses infected meat the fittings in it as well as the internal surfaces should be durable enough, and of such a nature as to withstand without damage repeated disinfection (Fig. 28).

The Manure Dump should be near the offal room but as far away as possible from the hanging room. Manure should not be kept on the premises for any length of time but removed at frequent intervals to a manure establishment at some distance from the town.

There should be *lavatory and latrine accommodation* for the staff. All appliances should be kept scrupulously clean and in good working order

Drainage.—The abattoir premises should be traversed by good macadamised and tarred paths and roads which can easily be kept clean. Good surface drainage should be provided and the surface water disposed of according to local conditions in a way to avoid mosquito nuisance.

The sullage waters from abattoirs are highly charged with putrescible organic material and are best dealt with by septic tank treatment before being further disposed of. If this is done the latrines may be fitted with water-closets connected up with the septic tank. For means of dealing with septic tank effluents, see pp. 252, 254

Water Supply —A large supply of pure water is needed in any abattoir for (*a*) consumption by the animals, (*b*) wiping down the carcasses during dressing, (*c*) the cleaning of tripe and guts, (*d*) the generation of steam and (*e*) general cleansing of all apart ments soiled during the course of the work.

The above account of the sanitary requirements of a small Municipal abattoir will give the inspector an idea of what to look for in making his inspection, apart altogether from the subject of meat inspection which has already been dealt with. It will also indicate the line to be followed in the inspection of private abattoirs.

Private abattoirs in my experience are generally an abomin ation because they are owned and worked by persons who do not have the means of providing suitable accommodation and whose methods are insanitary to a degree. They need constant super vision and one is left with the feeling that as soon as one's back is turned old methods prevail. They are often the scene of the illicit slaughter of diseased animals whose flesh is sold clandestinely at a cheap price. In the better ones there may or may not be lairage for the animals, generally a cowshed or shed constructed of wood, having a defective floor and impossible to keep clean. The slaughtering of the animals may be done in the open air in a small yard on the premises, surrounded by dwelling houses, or in a building as insanitary for its purpose as the lairage. Establishments of this kind cannot be made hygienic on account of the expense, and much the best thing to do about them is to persuade the Municipal Council to enact by-laws suppressing them altogether Should, however a butcher desire to have advice on the improvement of his premises the requirements of cowsheds (p 205) will, with appropriate modifications to suit the circumstances, give an indication for the lairage, and the account just given of the small Municipal abattoir contains all the material necessary for the re-designing of the slaughtering room.

In controlling the work of private abattoirs the inspector should not lay too great stress on minor structural defects. He should remember that the way in which the work is carried out is really of more importance to the public health than the pre mises on which it is done. All the measures and structural points which have been described have merely as their object the provision of the uncontaminated meat of healthy animals for human consumption. A moment's reflection will show that in this, as

in most other sanitary matters, the human element is the paramount one the others merely subsidiary and depending on it.

Butchers Shops

The following are the requirements for butchers shops

1 All butchers shops should be licensed and registered. The licence should be granted only if the premises answer the following requirements.

2. The premises should be roomy enough for the purpose for which they are intended, and properly furnished with all the necessary fittings.

3 The lighting should be adequate. Every part of the premises should be well lit by natural daylight.

4 Ample ventilation should be provided. The shop should feel well ventilated and fresh within the limits of local conditions.

5 Abundant water should be available on the premises.

6. The walls and floor of the shop should be constructed of hard, smooth, impermeable and easily cleaned material.

7 The shop should not communicate with a sleeping-room or a sanitary convenience, nor should any sanitary convenience or drain ventilate into it.

8. Covered metal water-tight bins should be provided for holding waste. These bins should not be kept inside the shop but outside.

9 Meat should be kept in fly proof cages having glass fronts.

10 Only meat bearing the meat inspector's stamp should be exposed for sale or sold.

In inspecting a butcher's shop the inspector should bear in mind the above. The licences should be issued yearly and there should be provision in the Municipal By-laws for the suppression of a licence if the premises are not kept in a satisfactory state or if meat other than that inspected by the meat inspector and duly marked is found on the premises. The smell of the shop should be noted. Does it smell sweet and clean? Is there evidence of congestion? Is the door surrounded with a ring of expectant mongrel dogs? If so, this points to improper disposal of waste the butcher is throwing out bones and scraps instead of putting them in the dust bin for removal and disposal by the scavenging staff Are the premises scrupulously clean? Look in corners What is the water supply? Is it safe? Is there

adequate provision for the cleansing of knives and vessels? Are the counters clean and is the clothing of the shopkeeper clean? Are his hands clean? Does all the meat bear a legible stamp of the meat inspector? Fraud is sometimes attempted by damping the mark on a marked piece and pressing an unmarked piece on the mark so as to obtain an impression of the mark. If the mark is distinct, this kind of fraud can be easily detected by the reversal of the lettering but if meat is allowed to leave the abattoir with blurred stamping on it, detection of this fraud is more difficult. It is therefore important to make sure that when meat is stamped the stamp should be clearly legible. In case of doubt give no hint to the shopkeeper of your suspicions but keep an eye on him until you can make sure. If he thinks he can deceive you once he will try again, and sooner or later you will catch him out. You should, however note in your diary on each occasion any suspicion you may harbour giving the reason for it as evidence, when you do have a case, that the fraud had probably been going on for some time. This may deprive an artful offender of the benefit of a First Offender's Act, if such exists.

Bakeries

The kinds of bread consumed in tropical countries differ In some places unleavened bread is the standard, in others leavened. The baking equipment therefore varies and the only satisfactory way for the inspector to acquaint himself with the various operations in which danger to the public health may arise is to watch the whole process from beginning to end. There are one or two general points which may be mentioned for his guidance.

The bakers should be clean and should wear clean overalls or aprons while at their work. Special attention should be paid to the trimming and cleanliness of their nails. Proper lavatory accommodation should be provided on the premises, though not communicating with the bakehouse directly The bakehouse should be an independent structure it should not communicate with a sleeping room, and fowls should be excluded from it.

The inner walls and floor of a bakehouse should be of smooth, durable, and impermeable material. They should be kept in good repair The construction of the building should be simple, and there should be no parts difficult of access since these are apt to become infested with rats and cockroaches. Rat holes

should be immediately blocked with broken glass mixed with cement mortar

The lighting of the bakehouse should be good and ventilation should be effected by direct communication with the external air

There must be plenty of water for cleansing. The water should be laid on to the premises if possible, and there should be no occasion for the storage of water in tubs since such water is seldom changed often enough. All washing receptacles should be emptied after use and properly scoured.

All vessels and apparatus in the bakehouse should be scrupulously clean. In places where leavened bread is made workmen should not be allowed to sleep in empty kneading troughs. This is a common practice in bakehouses where the dough is kneaded by hand because baking is done in the early hours of the morning and the men often prefer to sleep in the bakehouse rather than leave their homes to get to it during the night.

Spitting in the bakehouse should be prohibited.

No part of a bakehouse should be below the ground-level Underground bakehouses are almost invariably dark, dirty and ill ventilated.

No person should be employed in a bakery who has any abnormal condition of the skin. The employment of such a person should be a punishable offence.

The stokehole for the oven should be outside the bakehouse and fuel should not be stored in the same place as baking is carried out, since it may harbour vermin.

Proper dust-bins must be provided for refuse.

The materials used in baking must be pure, fresh and of good quality They should be stored either in a rat-proof store or in rat proof metal bins. The flour used should be free from vermin and clean.

The sanitary inspector should remember that the process of baking a leavened loaf probably does not disinfect the material in the interior For this reason the health of the workmen is an important thing to be seen to.

All bakehouses should be licensed and registered at the sanitary office. They should be frequently inspected and at these inspections the whole staff should be examined with regard to skin diseases, especially of the hands. Any worker with diseased hands should be referred to the Medical Officer of Health. A surprise inspection made in the early hours of the morning may

surprise more than the workmen the inspector himself may get a shock to see the kneading and mixing troughs occupied by sleeping members of the staff of the bakery

A Scheme for the Inspection of a Bakery

1 Inspect the bakery during working hours, obtaining from the Sanitary Authority a power of entry if necessary

2. Have the staff paraded and inspect their hands and nails. Note whether they are clean or dirty Any of the staff affected with skin disease? Are they wearing clean aprons or overalls?

3 Inspect the bakehouse. Is it clean, well lighted and ventilated?

4 Inspect the baking apparatus. Is it scrupulously clean?

5 Lavatory and latrine accommodation. Is it clean and in working order?

6. Inspect the materials in use. Take a sample of the flour for analysis (1 lb will be enough) Divide the sample into three approximately equal parts. Put each in a container in the presence of the manager or other responsible person and seal each one with the departmental stamp Give one to the manager after labelling it. Oblige the manager to countersign the labels. Label the others for office use one for analysis and one for production in court. All labelling and countersigning should be done in ink. Note evidence of gross pollution of flour or other substance used. Find out and note where the baker purchased his materials.

7 Are arrangements made for cleaning utensils satisfactory? Are all sinks, tubs and other containers clean?

8. Any evidence of vermin either inside or outside the bakehouse and stores. Evidence of rats? Flies?

9 Is the water supply pure? Where does it come from?

10 Are the premises in good repair or are there any structural defects which may cause nuisance (mosquito or rat)?

11 Are the premises clean or are they littered with rubbish? Are dust bins in use?

12. A sketch plan should be made showing the kinds of defects and nuisance if necessary

CHAPTER XIII

MILK

Milk forms the natural food of all young mammals. It is a mixture of several substances in water white in colour and liable to small variations in its composition. The average composition of cows milk is given in the table on p 176 Cows milk is the most commonly consumed, but the milk of goats buffaloes, camels, ewes and asses contributes to the dietary of different peoples.

All the important constituents of food are contained in milk Protein, known as casein, occurs in solution which is not affected by boiling The addition of rennet or acids causes the casein to fall out of solution in the form of curd. Fat occurs in milk in the form of a very fine emulsion. Since the fat is lighter than water it tends to rise to the surface of the milk, and when it does this it is known as cream Butter is solidified cream prepared from milk by churning it in special vessels. Ghi is butter which has been heated and clarified. The Arabic name for ghi, which is a Hindustani word, is dihn. Cheese consists of the casein of milk, drained under pressure and allowed to ripen. During ripening certain bacteria grow in the casein and cause the changes in it which give their distinctive character to the different cheeses Some cheeses contain cream as well as casein. Carbohydrate occurs in milk in the form of milk sugar and there are valuable mineral salts also present. Fresh milk contains all the known vitamins

Milk is a valuable food for infants and growing children. So far as the latter are concerned, removal of the fat by skimming does not impair its nutritive properties appreciably It should take a prominent place in the dietary of all human beings under eighteen years of age.

Owing to its nature milk is easily adulterated. An appreciable amount of water may be added to it without altering its appearance, and it may be impoverished by skimming and still look

surprise more than the workmen the inspector himself may get a shock to see the kneading and mixing troughs occupied by sleeping members of the staff of the bakery

A Scheme for the Inspection of a Bakery

1 Inspect the bakery during working hours, obtaining from the Sanitary Authority a power of entry if necessary

2. Have the staff paraded and inspect their hands and nails. Note whether they are clean or dirty Any of the staff affected with skin disease? Are they wearing clean aprons or overalls?

3 Inspect the bakehouse. Is it clean, well lighted and ventilated?

4 Inspect the baking *apparatus. Is it scrupulously clean?*

5 Lavatory and latrine accommodation. Is it clean and in working order?

6 Inspect the materials in use. Take a sample of the flour for analysis (1 lb will be enough). Divide the sample into three approximately equal parts. Put each in a container in the presence of the manager or other responsible person and seal each one with the departmental stamp Give one to the manager after labelling it. Oblige the manager to countersign the labels. Label the others for office use one for analysis and one for production in court. All labelling and countersigning should be done in ink. Note evidence of gross pollution of flour or other substance used. Find out and note where the baker purchased his materials.

7 Are arrangements made for cleaning utensils satisfactory? Are all sinks, tubs and other containers clean?

8. Any evidence of vermin either inside or outside the bake house and stores. Evidence of rats? Flies?

9 Is the water supply pure? Where does it come from?

10. Are the premises in good repair or are there any structural defects which may cause nuisance (mosquito or rat)?

11 Are the premises clean or are they littered with rubbish? Are dust bins in use?

12. A sketch plan should be made showing the kinds of defects and nuisance if necessary

CHAPTER XIII

MILK

MILK forms the natural food of all young mammals. It is a mixture of several substances in water white in colour and liable to small variations in its composition. The average composition of cows milk is given in the table on p 176. Cows milk is the most commonly consumed, but the milk of goats, buffaloes, camels, ewes and asses contributes to the dietary of different peoples.

All the important constituents of food are contained in milk. Protein, known as casein, occurs in solution which is not affected by boiling The addition of rennet or acids causes the casein to fall out of solution in the form of curd. Fat occurs in milk in the form of a very fine emulsion. Since the fat is lighter than water it tends to rise to the surface of the milk, and when it does this it is known as cream. Butter is solidified cream prepared from milk by churning it in special vessels. Ghi is butter which has been heated and clarified. The Arabic name for ghi, which is a Hindustani word, is dihin. Cheese consists of the casein of milk drained under pressure and allowed to ripen. During ripening certain bacteria grow in the casein and cause the changes in it which give their distinctive character to the different cheeses Some cheeses contain cream as well as casein. Carbohydrate occurs in milk in the form of milk sugar and there are valuable mineral salts also present. Fresh milk contains all the known vitamins

Milk is a valuable food for infants and growing children. So far as the latter are concerned, removal of the fat by skimming does not impair its nutritive properties appreciably It should take a prominent place in the dietary of all human beings under eighteen years of age.

Owing to its nature milk is easily adulterated. An appreciable amount of water may be added to it without altering its appearance, and it may be impoverished by skimming and still look

rich to the eye. These means of fraud are largely practised by unscrupulous dairymen and can only be detected by having the milk chemically analysed. Fraud of this kind can be controlled only by frequent sampling and by the infliction of heavy fines or even imprisonment upon dishonest vendors.

The Sampling of Milk for Analysis

An important part of the inspector's work is the taking of samples of foodstuffs for analysis. With regard to milk there are one or two points which must be scrupulously observed if a successful prosecution is to be entered against an offender The procedure recommended is as follows

1 The inspector should provide himself with the following Clean 8-oz. medicine bottles, corks to fit, white paper small metal discs of the same diameter as the mouths of the bottles, a pen knife, cotton tape, sealing wax, the departmental seal, adhesive labels and a bottle of formalin.

2. The party concerned must be informed that samples are going to be taken for analysis. This is done at the moment of sampling

3 The milk to be sampled must be thoroughly mixed, either by pouring it from one vessel to another several times or by filling a large measure and pouring the contents back into the container a number of times. Mixing done in this way is essential to get a sample of uniform quality Stirring the milk round with a stick or a spoon does not mix it properly because it does not dislodge the upper layers of the milk which are richer in cream than the lower

4 The milk to be analysed is poured into three of the clean sample bottles. Thirty drops of formalin are added to each sample which is then securely corked. The formalin prevents the sample from curdling and does not interfere with the accuracy of the analysis. The corks are then cut flush with the tops of the bottles.

5 A metal disc is placed over each cork and covered with a piece of white paper of suitable size which is then secured to the top and neck of the bottle with the tape. The departmental seal is then affixed to all the bottles on the top and in front so as to fix the ends of the tape by the seal to the bottle.

6 A label is then pasted on the front, or back of each bottle. On each label is written with ink or indelible pencil (*a*) the

name of the milkman, (*b*) place sample taken, (*c*) time sample taken, (*d*) date sample taken.

7 All this should be done in the presence of the milkman who should be required to counter initial each label. One sample should then be handed to the milkman, the other two being retained by the inspector One of these is sent for analysis, the other is kept for production in court in case the milkman contests the analyst s findings. In such a case the magistrate or judicial officer may require the remaining sample to be analysed by an analyst of his choice.

The metal disc and paper cover have been found necessary to prevent traders from tampering with their samples before sending them to an analyst whom they intend to call in their defence. An ingenious operator can pierce a sealed cork with a hypodermic needle, withdraw the milk from the bottle and replace it with perfectly good milk without leaving any sign that the sample has been tampered with. He hopes in this way to throw discredit on the method of sampling, raise a doubt in the mind of the magistrate and get acquitted in consequence.

All sampling sealing and labelling should take place in the presence of the milkman.

Duplicates of samples sent for analysis should be kept under lock and key in an ice chest until the case has been disposed of

The Hygiene of Milk Production

One useful safeguard to the health of the community in the tropics is the almost universal habit of boiling the milk immedi ately upon receipt. This does not, however absolve the Sanitary Authority from the duty of taking all possible measures to ensure that the raw milk is produced in a sanitary way and is marketed hygienically

Cowsheds

Cowsheds in the tropics may become a nuisance in several ways

(*a*) Fly nuisance from the manure.
(*b*) Mosquito nuisance from the sullage waters.
(*c*) Rat nuisance.
(*d*) A source of the spread of the milk borne diseases milk-borne diseases are as follows

Common to cattle and man.	Not affecting cattle but spread by milk infected by human beings.
Bovine tuberculosis. Undulant fever Foot and mouth disease. Milk sickness.	The typhoid fevers. Diphtheria. Scarlet fever Septic sore throat.

The rat and mosquito nuisance can be avoided by good construction combined with the intelligent application of simple sanitary measures. The liability to the spread of disease depends almost entirely upon the intelligence and citizenship displayed by those in the trade.

The essential part of any cowshed is the floor and the immediately surrounding area. A cowshed cannot be conducted in a sanitary manner unless the *floor is of stout construction*, impermeable to water and properly drained. The area of ground surrounding the cowshed should be levelled off and rolled so as to allow easy drainage and to support any drains found to be necessary Cement concrete is much the best flooring for cow sheds since it is a hard and durable material impervious to water It is plastic and can therefore be moulded to requirements, channels may be easily made in it as it is being laid down and these may readily be given the slope necessary to ensure rapid *and complete drainage. Where stone or brick are used for the* flooring of cowsheds they should answer the requirements of hardness and impermeability to water met by cement concrete. The stone should be well dressed and both stone and brick floors laid on a firm foundation so as to prevent subsidence and interference with free drainage. They should be pointed with cement mortar

A cowshed constructed to hold one or two cows *only* is unlikely to be deficient in lighting cubic capacity and ventilation. *So long as its floor answers* requirements, the rest of the structure will need only ordinary care and maintenance to keep the shed in a sanitary state. When, however a number of animals are housed in the one building, attention must be paid to matters other than the floor In such a building the specification for each cow is as follows Length of stall, including manger 8 feet width of stall, 3 feet 6 inches surface area, 50 square feet cubic capacity *800 to 1 000 cubic feet lighting* 3 square feet of window Behind the stalls there should be a properly graded

manure channel 2 feet wide and 4 inches to 6 inches deep leading to the outside.

A good type of cowshed for a herd is illustrated in Figs. 29

Fig. 29.—Hygienic cowshed for a herd.
The drawing is broken at both ends to save space. The individual watering vessels are not shown.

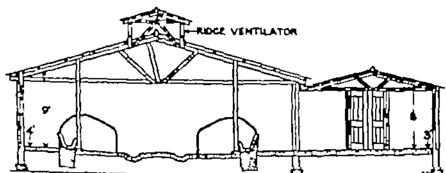


Fig. 30.—Section along AB of Fig. 29

and 30. Note (*a*) plenty of lighting space, (*b*) the central dunging passage, (*c*) the cattle face outwards and each has its own manger which is low and allows the cow to lie down without

Common to cattle and men.	Not affecting cattle but spread by milk infected by human beings.
Bovine tuberculosis. Undulant fever. Foot and mouth disease. Milk sickness.	The typhoid fevers. Diphtheria. Scarlet fever Septic sore throat.

The rat and mosquito nuisance can be avoided by good construction combined with the intelligent application of simple sanitary measures. The liability to the spread of disease depends almost entirely upon the intelligence and citizenship displayed by those in the trade.

The essential part of any cowshed is the floor and the immediately surrounding area. A cowshed cannot be conducted in a *sanitary manner unless the floor is of stout construction*, impermeable to water and properly drained. The area of ground surrounding the cowshed should be levelled off and rolled so as to allow easy drainage and to support any drains found to be necessary Cement concrete is much the best flooring for cow sheds since it is a hard and durable material impervious to water It is plastic and can therefore be moulded to requirements, channels may be easily made in it as it is being laid down and these may readily be given the slope necessary to ensure rapid and complete drainage. Where stone or brick are used for the flooring of cowsheds they should answer the requirements of hardness and impermeability to water met by cement concrete. The *stone should be well dressed and both stone and brick* floors laid on a firm foundation so as to prevent subsidence and interference with free drainage. They should be pointed with cement mortar

A cowshed constructed to hold one or two cows only is un likely to be deficient in lighting, cubic capacity and *ventilation.* So long as its floor answers requirements, the rest of the structure will need only ordinary care and maintenance to keep the shed in a sanitary state. When, however a number of animals are housed in the one building, attention must be paid to matters other than the floor In such a building the specification for each cow is as follows Length of stall, including manger 8 feet width of stall, 3 feet 6 inches surface area, 50 square feet cubic capacity 800 to 1 000 cubic feet lighting, 3 square feet of window Behind the stalls there should be a properly graded

manure channel 2 feet wide and 4 inches to 6 inches deep leading to the outside.

A good type of cowshed for a herd is illustrated in Figs. 29

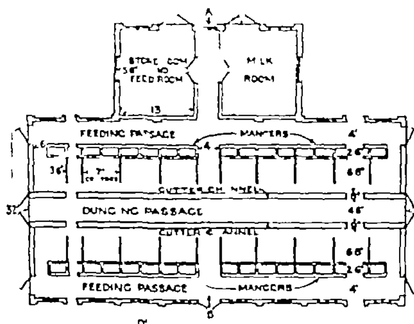


FIG. 29.—Hygienic cowshed for a herd.
The drawing is broken at both ends to save space. The individual watering vessels are not shown.

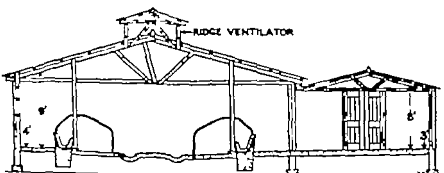


FIG. 30.—Section along AB of Fig. 29

and 30. Note (*a*) plenty of lighting space, (*b*) the central dunging passage, (*c*) the cattle face outwards and each has its own manger which is low and allows the cow to lie down without

having to step back, (*d*) the absence of superfluous fittings and partitions so that cleanliness is easily maintained and there is no shelter for rats, (*f*) the absence of corners in the construction of the mangers, and (*g*) the feeding passages between the cattle and the walls. In the cowshed of which the figure is the drawing the water was laid on to the stalls through faucets which the cows could work themselves. This saves work and is economical in water The walls of the shed are of brick and the space between them and the cattle prevents them from becoming fouled. They are periodically limewashed.

As a general rule, animals should not be kept in contact with any of the walls of the shed because they are apt to foul them very badly and so necessitate extra work for the staff If they are so kept the walls should have a hard, smooth, impermeable surface for a height of 6 feet, so that they may be effectively cleaned each day

The disposal of the dung and the waste waters will be regulated by the means available. In sewered areas the liquids should be drained into a trapped gully giving access to the sewers. In areas where there are no sewers the liquids should be led into a water tight sump pit which is emptied periodically the contents being disposed of elsewhere. The emptying and disposal of the contents should be done by the Local Authority Sump pits should have an intercepting trap interposed between them and the cowshed drain they should be mosquito-proofed by being fitted with a good iron cover and the intercepting trap should be oiled regularly to prevent mosquito breeding in it. All sump pits should be situated outside the cowshed there should be no retention of dung or waste liquids inside the cowshed itself

The soiled bedding and dung are usually kept for conversion into manure, which is either used by the dairyman himself or sold to cultivators. Before the straw has any manurial value it must rot and the rotting is carried out by stacking the manure in heaps or packing it in pits. While this is going on it is apt to cause a considerable house fly nuisance because fresh manure is very attractive to flies, which find in it the ideal material to lay their eggs. For this reason the preparation of manure should not be allowed in closely built areas such as villages and towns. Fly breeding may be considerably reduced by paying attention to the following methods.

Prevention of Fly breeding in Stable and Cowshed Manure

The prevention of fly breeding in stable manure is based on the following observations

(*a*) Flies will lay their eggs only on fresh manure old rotted manure is not at all attractive to them

(*b*) Fermentation in the middle of a well packed manure heap results in the evolution of heat and the temperature is high enough to kill fly eggs and larvae in a few minutes.

(*c*) When the fully grown fly larva is about to pupate it leaves its feeding place and burrows into the ground at some distance away

Packing —The efficacy of this method depends on (*b*) above A piece of ground 3 yards wide and any convenient length is selected and is made hard and smooth by rolling or by rolling and oiling with heavy oil (1 pint per square yard). Channels 2 feet wide are dug round the oiled piece Manure is stacked at one end being tightly packed layer by layer When it reaches a convenient height the top is flattened and the end and two sides are smoothed and sloped towards the channels The earth from the channels is mixed with water and applied to the top end and sides of the heap until the manure is covered with a layer of some 6 inches of mud. Heat is generated in the heap which grows by the addition of manure to the open end and as it grows the new additions are in their turn covered with the mud When the heap is big enough the fresh manure, instead of being merely packed at the end is buried in the middle of the heap the fermented manure removed from the middle being used to cover the fresh. When the heap reaches a convenient size it is sealed off with mud and another begun.

Baber's Method.—This depends on (*c*) above The manure is surrounded with an impermeable area draining into a channel of such a shape as to prevent any larvae which fall into it from crawling out again. The trapped larvae are periodically collected and burnt, or the channel may be kept half filled with water in which there is disinfectant fluid or on which floats a film of oil. In either case the larvae are killed. Baber's method for temporary heaps makes use of sheet metal gutters which are carried under the outer edges of the dump for about 16 inches to prevent the larvae from burrowing into the ground. These gutters are made

in lengths of 15 feet. The method of working such a dump is as follows (see Fig 31)

The site of the dump should be roughly rectangular On a suitable level gutters with inlay are laid down along both sides (AA, BB) and also at CC where dumping will begin, a little earth being removed to allow these gutters to bed firmly The ends of each gutter and its inlay are placed overlapping the next. Larvæ are prevented from escaping at the corners (AC and CB)

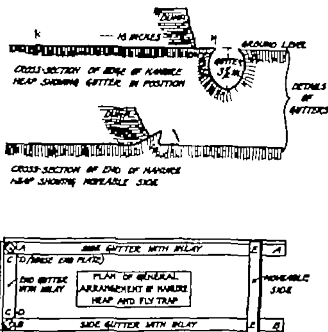


Fig 31 —The Baber fly-preventing method of dealing with manure. (*Kirk : Public Health Practice in the Tropics.*)

by two small plates (DD) At the other end (EE) is a length of gutter and inlay shaped to permit it being moved this gutter is not sunk into the ground, nor are its ends closed, the larvæ from it falling into the side gutters.

Beginning at the end (CC) the first day's manure is tipped over the space bounded by the two side gutters and as close to them as possible. The second day's manure is stacked above the first and the third day's above the second, and so on until the dump is about 10 feet high. About the end of the fifth week the manure dumped during the first week will now be dead

and free of larvæ the first lengths of guttering may be lifted and relaid at the opposite end and dumping continued.

For permanent establishments a concrete platform surrounded with similar gutters may be used (Fig 32)

Large dairy establishments in the tropics should have the cows periodically tested by means of the tuberculin test (see p 66) and infected cows removed immediately If the cattle are stalled

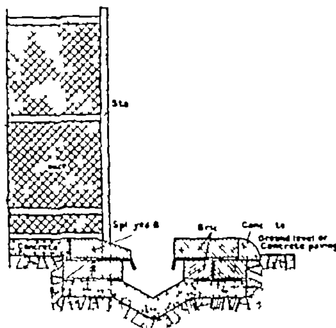


FIG 32.—Construction of the Baber gutter maggot trap for permanent manure dumps.
(After *Practical Tropical Sanitation*.)

in a well-lit and ventilated cowshed the chances of infecting other cows from a tuberculous cow are greatly lessened. The discovery of an infected cow should mean the thorough disinfection of the whole cowshed. No new cow should be admitted to a dairy herd until it has been tested and found free from tuberculosis.

The Hygiene of Milking

Abundant water of good quality should be laid on to any premises used as a dairy Lavatory accommodation should be provided for the workers where they may wash their hands thoroughly before beginning milking The cows should be clean and

A Scheme for the Inspection of Cowsheds or Dairy Premises

1 The dairy should be visited during working hours.

2. Proceed at once to the cowshed and watch the milking As opportunity offers inspect the milkers. Do any suffer from skin disease, chronic cough (tuberculosis) or any affection of the hands ? Are their hands and nails clean ? Are they dressed in clean overalls ? Note the state of the cows. *Do they look healthy ?* Are any thin or in bad condition ? Are they well groomed ? Is there litter in the stalls or has it been removed before milking has begun ? (*It should be.*) *Are the milk pails clean and do they smell sweet ?*

3 Inspect staff lavatories. Are soap nail brushes and clean towels provided ? Are the lavatories clean or dirty ? Note any defects which should receive attention.

4 Note the general state of cleanliness of the cowshed. Are the roof, walls, and floor in good condition ? Any evidence of rats ? Are flies numerous ? Cause a bucket of water to be poured into the drainage channel at its upper end and see if it drains freely to the outside.

5 Visit the milk room. Is the cooler in working order and is it being used ? Is the room clean and sweet ? Are the utensils and bottles clean and sweet ? (smell them). Is the fly screening in good condition ? Is the general upkeep satisfactory ?

6 Visit the boiler room. Is the water supply wholesome ? Where does it come from ? If a well, is it properly constructed ? Are the arrangements made for the washing and scalding of the utensils satisfactory ? Are all water taps in good condition ?

7 Survey the surroundings. Are they tidy ? Any sign of rats ? Any rat harbourage ? Any mosquito nuisances ? Is the sump pit working ? Is it mosquito-proof or does it contain mosquito larvæ ? If so, collect a number of larvæ for identification. Manure. Is it removed periodically ? If so, how often ? If kept on premises, for how long at a time ? Is the heap or pit tidy and are flies numerous ? Are there any other nuisances requiring attention ? What are they ?

8. Is the cowkeepers licence in order ?

9 Call for the veterinary certificates regarding the tuberculin

tests. Compare them with the cows in the cowshed. Are there any discrepancies? If so, what are they and what is the explanation offered by the cowkeeper? Are there any animals in the herd which have not yet been tested? When did they come? Why have they not been tested?

10 From the above, what is your opinion on the practice of the cowkeeper concerned? Is he reliable or not? What should be specially noted in subsequent inspections?

11 Next inspection to be made on.

CHAPTER XIV

WATER AND WATER SUPPLIES

WATER is essential to life and the provision of an ample supply of pure wholesome water is one of the primary duties of a Local Authority

Water exists in nature as a gas, a liquid and a solid, depending upon the temperature. At sea level it turns solid at a temperature of 0° Centigrade, which is known as the freezing point of water and it becomes a gas at a temperature of 100° C. which is the boiling point of water When water is in contact with the air it evaporates at all temperatures and is absorbed by the air as a gas, so that even over waterless deserts the air is never absolutely dry Water is one of the most powerful solvents known and because of this it is never found in nature in the pure state.

Water reaches the earth s surface as dew rain, snow or hail, according to the temperature of the air at which the condensation of the atmospheric water vapour occurs. The water falling on the surface of the earth is partly absorbed into the soil, partly evaporated into the atmosphere, and partly run into the sea as streams and rivers. When water falls upon an impermeable part of the earth s surface which is situated in a hollow a lake is formed.

The crust of the earth is not uniform. It consists of a vast number of different substances, some of which are permeable to water and some impermeable. In many parts of the earth s surface these substances occur in layers or strata, which in the course of countless ages have been twisted, broken, compressed, sundered or worn. On the surface of the earth these natural processes have left their traces as mountain ranges, plains, canyons and valleys below the surface the same irregularities exist and it is owing to them and to the subsidence of extensive areas of the earth s crust that vast underground stores of water exist.

Amount of Water necessary—The minimum amount of water for which provision should be made is 15 to 25 gallons per head

per day This will provide enough for all domestic purposes The minimum amount of *drinking* water necessary in the hotter regions of the tropics is 5 gallons per head per day

Domestic animals require the following amounts

Horse mule or ox	10 gallons per day
Sheep pig or goat	1 "
Camel	10 "

The requirements of a wholesome drinking water are the following

1 It should be without taste, smell or colour

2. It should not contain an undue amount of solid constituents

3 *It should be free from nitrogenous organic matter*

4 It should not contain nitrites or poisonous substances, e g lead or arsenic.

5 It should not contain pathogenic bacteria.

Sources of Supply

The sources of supply of water for households and communities are as follows

(*a*) The sea by distillation.
(*b*) Rain-water collected on the premises.
(*c*) Wells, including infiltration galleries (underground waters).
(*d*) Springs }
(*e*) Rivers and streams } Surface waters.
(*f*) Lakes }

Distillation.—Rarely met with. Sometimes used in military campaigns, and on ships. Occasionally used as a temporary supply when the normal supply is exhausted.

The raw water which is to be distilled, if fresh, should be un polluted. If water from a polluted source is taken, unpleasant tasting or smelling substances may pass over in the distillate. Remember also that distilled water is a strong solvent of lead so that there should be no lead in contact with it either in the distilling plant or during storage and distribution. When sea water is used a certain amount of the crude water may pass over into the distillate, giving it a brackish taste. This points to a defect in the distilling plant.

Rain-water—In some parts of the world rain-water is col lected from the house roofs and stored for use in tanks or under ground reservoirs. Rain-water is very nearly pure water and the

same precautions regarding the elimination of lead from the installation should be taken as with distilled water

One or two points are useful

1 The first rain to fall on the roof becomes contaminated with dirt and the droppings of birds. One can obtain mechanical

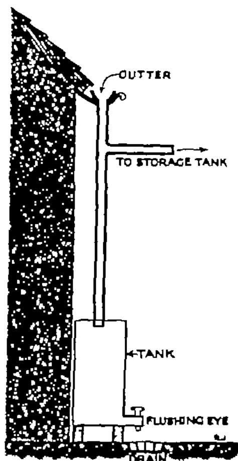


FIG. 34—A simple rain-water separator For description see text

separators which automatically reject the first washings. The same object can be effected by angled pipes as shown in the illustration. When rain falls the first washings run into the tank through the vertical pipe. By the time the tank and vertical pipe are full, enough rain has fallen to wash the roof and the clean rain-water flows through the angle piece to the storage tank. The pipe should enter the tank through a water tight joint.

2. Water tanks should be of iron, cement, or masonry lined

with cement. The pipe leading into them should be drowned by being carried to within a few inches of the bottom of the tank. Water should be withdrawn from the tank by a tap placed high enough to avoid disturbing the sediment which may deposit. All such storage reservoirs should be covered over with well fitting mosquito-proof covers and the hole through which the filling pipe enters the tank made mosquito-proof also. By the above mentioned arrangement the tanks are made practically inaccessible to domestic mosquitoes.

Wells—Wells are shafts sunk into the ground so as to reach the underground water

Well water is generally wholesome in the natural state. It may contain inorganic salts in solution and if the water is derived from limestone formations it may be hard. The salts dissolved in the water may give it a slightly brackish taste. If the water percolates through iron-containing rocks or soil it may contain salts of iron in solution which give the water a disagreeable taste and stain clothing washed in it. It may also give rise to disorders of digestion.

Wells are classified as *shallow deep* and *artesian* Shallow wells are those which extend down to the water lying on the upper most impermeable layer of the soil whether it be clay or rock. They do not penetrate this layer The term shallow has nothing whatever to do with the depth of the well in feet. It is used to denote a well which does not penetrate the uppermost impermeable layer of the soil. A deep well is a well which penetrates the uppermost impermeable layer of the soil and taps the water lying above the next impermeable layer

An artesian well is a well which taps water lying under sufficient pressure to force it to the well-head.

Speaking generally the water of shallow wells is more likely to be dangerous than that of deep wells. The water of deep wells and of artesian wells is of high bacteriological purity but is more likely to contain chemical salts than shallow well water

Shallow Wells—These tap the superficial ground water Sometimes the water table (the upper surface of the ground water) is very near the surface of the soil and thus runs the risk of being polluted by human excreta being forced down into it during heavy rains in areas where surface pollution of the soil is common. But the chief dangers of contamination of the ground water with human or animal excreta do not arise so much through

natural agencies as by man's own actions. He may construct pit latrines or leaching cesspits whose contents may ooze into the ground water and spread contamination through a considerable area. The danger from such sources is, however not very great, and diminishes substantially the farther away one gets from the source of contamination. At a hundred feet distance the risk of dangerous pollution is practically negligible unless the ground is fissured.

Deep Wells.—The risk of cesspits and pit latrines contaminating the water tapped by deep and artesian wells is quite negligible if the well-shafts are made impermeable to water Contaminated ground water may seep through the wall of the shaft of a badly constructed deep well and thus contaminate its contents.

Contamination of Well Water—The greatest risk of contaminating well water comes from the well head. It may occur in the following ways

(*a*) Bathing on the well head and letting the used water fall back into the well.

(*b*) Washing clothes on the well head or on the parapet.

(*c*) Resting the bucket on ground contaminated with soil from the feet of the users. Each time the bucket is used, further contamination of the water is caused.

(*d*) Washing out the mouth and spitting into the well.

(*e*) Having a defective parapet which allows waste water round the well head to trickle back into the well.

(*f*) Defective construction of the shaft of the well allowing the access of the upper layers of the ground water which are the most likely to be polluted. The growth of ferns in the upper parts of wells is a fruitful cause of defect in the shaft.

Step wells are wells which have a flight of steps extending from the ground-level to the water-level. They are usually only used for ceremonial purposes the water is invariably grossly polluted and should always be regarded as unsafe.

Hygienic Well Construction.

1 *Shaft.*—The shaft should be impermeable to water at least to the water level. In a deep well it should be impermeable to the first impermeable layer (Prevents ground water in which there is a possibility of contamination from seeping through the shaft into the well.) This is effected by constructing

a ring of clay all round the outside of shaft when the well is being built or it may be done by making a similar sheath of cement concrete.

2. *Mouth.*—The shaft should be carried well up above the level of the surrounding ground in the form of a parapet or coping. This is to prevent flood water from entering the well.

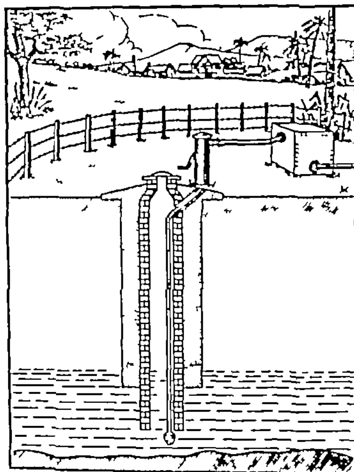


Fig. 35.—Properly constructed well showing features described in the text.

3. The immediate surroundings on the well should be fenced off, if this can be done, on a radius of about 100 feet. Even if one cannot get this radius, a smaller radius is better than nothing.

4. *Water Lift.*—Pump. A simple form of hand pump is the

natural agencies as by man's own actions. He may construct pit latrines or leaching cesspits whose contents may ooze into the ground water and spread contamination through a considerable area. The danger from such sources is, however not very great and diminishes substantially the farther away one gets from the source of contamination. At a hundred feet distance the risk of dangerous pollution is practically negligible unless the ground is fissured.

Deep Wells.—The risk of cesspits and pit latrines contaminating the water tapped by deep and artesian wells is quite negligible if the well-shafts are made impermeable to water. Contaminated ground water may seep through the wall of the shaft of a badly constructed deep well and thus contaminate its contents.

Contamination of Well Water.—The greatest risk of contaminating well water comes from the well-head. It may occur in the following ways

(*a*) Bathing on the well head and letting the used water fall back into the well.

(*b*) Washing clothes on the well head or on the parapet.

(*c*) Resting the bucket on ground contaminated with soil from the feet of the users. Each time the bucket is used, further contamination of the water is caused.

(*d*) Washing out the mouth and spitting into the well.

(*e*) Having a defective parapet which allows waste water round the well head to trickle back into the well.

(*f*) Defective construction of the shaft of the well allowing the access of the upper layers of the ground water which are the most likely to be polluted. The growth of ferns in the upper parts of wells is a fruitful cause of defect in the shaft.

Step wells are wells which have a flight of steps extending from the ground level to the water level. They are usually only used for ceremonial purposes the water is invariably grossly polluted and should always be regarded as unsafe.

Hygienic Well Construction.

1 *Shaft*.—The shaft should be impermeable to water at least to the water level. In a deep well it should be impermeable to the first impermeable layer (Prevents ground water in which there is a possibility of contamination from seeping through the shaft into the well.) This is effected by constructing

a ring of clay all round the outside of shaft when the well is being built or it may be done by making a similar sheath of cement concrete.

2. *Mouth*.—The shaft should be carried well up above the level of the surrounding ground in the form of a parapet or coping. This is to prevent flood water from entering the well.

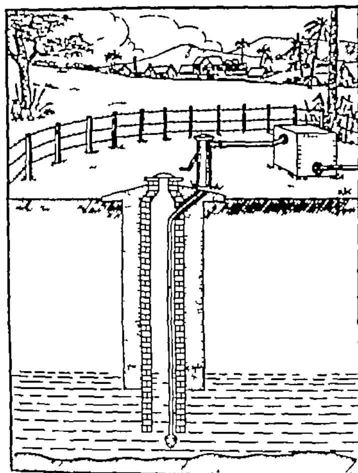


FIG. 35.—Properly constructed well showing features described in the text.

3. The immediate surroundings on the well should be fenced off if this can be done, on a radius of about 100 feet. Even if one cannot get this radius, a smaller radius is better than nothing.

4. *Water Lift*.—Pump. A simple form of hand pump is the

most satisfactory because it enables the top of the well to be completely covered in. The pump should be fixed to one side of the well so as to obtain a firm base, and be connected with the vertical pipe which draws the water by an angle piece of piping A simple suction pump depends upon the atmospheric pressure it is really the weight of the atmosphere which forces the water up the pipe on the action of the pump and as the weight of the atmosphere is about equal to that of a column of water some 28 feet high, this is the maximum height to which water can be raised by a simple suction pump. If the well is deeper than this, another type of pump must be used. The semi rotary hand pump has a lift of 70 feet. A hand pump is suitable only for small communities (see Fig 35).

For larger villages the bucket, with or without a windlass, is *the only alternative to the more expensive power pumps.*

An excellent type of bucket well head is shown in Fig 36.

SPECIFICATION OF SANITARY WELL PARAPET—No 1

The parapets should be constructed of brick-in lime mortar Only first-class materials should be used and the work should be executed in a careful and workmanlike manner The steining wall should be 1 foot 3 inches thick, and the parapets 3 feet 9 inches in height above the platform. The openings of 1 foot 6 inches at the inner face, and 2 feet at the outer face of the steining wall should be made for facility of taking out the buckets at a height 2 feet 6 inches above the platform. The tops of parapets should be levelled 5 inches at the inner face of the steining wall and then sloped 1 inch to a foot outwards. *Glazed bricks or stones set in cement mortar should be placed in the openings for the buckets as shown in the plan.* The pillars are to be 2 feet 1 inch long, 1 foot 3 inches broad, and 1 foot 6 inches in height above the parapets. The iron rails are to be placed at a height *of 4 feet 3 inches* above the platform or 6 inches above the parapet with tops downwards. Six inch diameter anti friction or wooden rollers are to be fixed on the rails and the clearance between the rails and rollers should not exceed 1 inch. The centre of the rollers or rails should be at a distance not exceeding 6 inches from the inner face of the steining wall. The dimensions given below should be strictly followed and the anti friction rollers or wheels should be fitted on to the rails before the latter are built in. A brick-on-edge platform over a layer of brick

flat with a slope of an inch to a foot should be provided A catch water drain with an outlet should also be provided for the discharge of spill water The parapets, pillars and platforms are to be pointed with cement and sand.

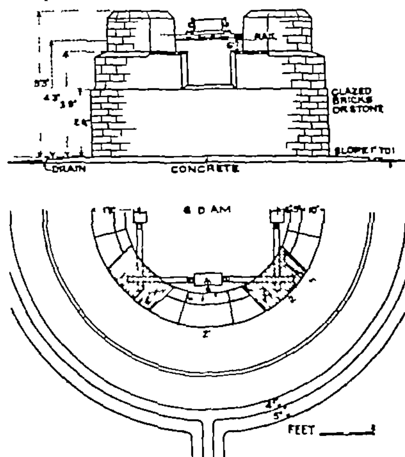


FIG. 36—Sanitary draw well parapet designed by the Asansol Mines Board of Health.

	ft.	in.
Total height	5	3
Height of parapet	3	9
Height of bottom of rail above platform	4	3
Height to opening	2	6
Distance of centre of rail or anti-friction rollers from inner edge of steining wall	0	6"

To calculate the yield of a well—

(*a*) take the water level

(*b*) pump out or otherwise withdraw as large a quantity of water as possible in the time available
(*c*) take the level of the well and note the time
(*d*) allow the well to fill to its former level and note the time;

$$\text{Then the yield per hour} = \frac{\text{the quantity of water replaced}}{\text{time in hours } (d - c)}$$

The quantity of water replaced Sectional area of the well in square feet × distance in feet between the normal water level and the level to which the water was pumped down. This is expressed in cubic feet. Multiply by 6·23 *to find the number* of gallons.

The same thing may be expressed by the following formula

$$\text{Yield in gallons per hour} = \frac{D \times A \times 6{\cdot}23}{T}$$

Where D = *The difference in level caused by the pumping,* expressed in feet.
A = The sectional area of the well in square feet.
T = The time taken to regain the normal water-level (in hours).

Springs—Though springs have been included in the classi*fication of surface waters they are really subsoil waters appearing* on the surface of the earth at the point where an impermeable layer reaches the surface, or at a point which represents the overflow level of some subterranean collection of water at a distance.

Spring water is usually organically pure as it reaches the surface of the soil and pollution generally takes places from the ground in the vicinity

Springs may flow continuously or may be intermittent. For the latter reason their past history especially in dry years should be carefully ascertained before they are used as the water supply of a community

Spring water may be protected by excavating some distance into the soil and constructing a cement basin into which the water discharges. The basin should be covered over and the water discharged from it through a pipe. Around the spring area there should be dug a good catch water drain and additional protection may be given by surrounding the area by a wall built inside the drain.

Below the discharge pipe a good masonry or cement drain

should be made to take the surplus water away In the course of this drain a watering trough for animals may be constructed and below the watering trough there may be arrangements for the washing of clothes.

Rivers—The hygienic quality of river water depends largely upon the number of villages along the course of the river The smaller the river and the greater number the villages the more likelihood is there of the water being polluted to a dangerous degree.

Two things serve to reduce the risk of bacterial pollution of rivers (*a*) the sterilising effect of the sun and air on the water and (*b*) the amount of dilution which takes place when sewage enters the water It is clear that a large slowly flowing river has a considerable part of its area exposed to the sun's rays during most of the day and that the dilution of any sewage entering it must be enormous. The smaller the stream and the more sheltered it is, especially as is often the case when its flow is retarded by obstructions, the more chance there is of pathogenic bacteria surviving after they gain access to the water

The most primitive form of river sanitation is to zone the banks and oblige the people to take their drinking water from the highest point of the stream convenient to all. The watering of domestic animals, bathing, and the washing of clothes can then be carried out in successive zones downstream. Concurrently with this, arrangements will be made for the installation of latrines on domestic premises so as to prevent soil pollution. This may answer well so long as the nearest up-stream village is some considerable distance away where presumably the same measures will be taken.

An improvement on this method where conditions permit is to construct a dam over the river fairly high up-stream and lead the water to the village by a pipe line The water is stored in a tank or a distributing reservoir constructed at some convenient place and is piped into the village where it is made available to the public either through public standpipes or by laying it on to private premises. When this is done the area of land which drains into the river above the dam and is known as the *catchment area* should be depopulated and no human occupation allowed.

River water varies in quality with the season. During the rains it may be turbid and contain a large amount of organic

matter in suspension. It is generally soft, but may be brown if the catchment area contains *peat moss*. Large waterworks using river water have frequently to make special arrangements for the sedimentation of the suspended matter before treating the water prior to distribution.

The calculation of the yield of water from a stream may be made as follows

Select a fairly straight length of about 20 yards where the channel is fairly uniform, and there are no eddies. Measure the breadth and depth at three or four places and from these obtain the average sectional area of the channel Drop in a cork or a small piece of light wood and note the time in seconds it takes to travel a measured distance, say 30–40 feet then if V = the surface velocity of the stream in feet per second and A = the sectional area of the channel in square feet (the average breadth of the channel in feet × the average depth of the channel in feet)

then $\frac{4}{5}V \times A$ = the yield in cubic feet per second

and $\frac{4}{5}V \times A \times 6.23 \times 60$ = the yield in gallons per minute.

Lakes—Lake water is generally clear because it has had time to deposit its sediment, and in the natural state it is pure because of its exposure to the sun and air

Communities living near lakes generally take their water from the lake-side. Here again zoning may be of use, or light jetties may be constructed so as to enable people to obtain the water at some distance from the shore and so further from the area of pollution.

Tanks—Tanks are large excavations in the neighbourhood of villages in which surface water is led for storage as the village water supply Many of these are extremely insanitary since in some localities the surface drainage of the village discharges into them, animals are driven into them to water the village washing is done in them and they are also used as bathing pools. Where a number of tanks exist some should be reserved for domestic water others for animals and other uses. Those reserved for domestic use should be well banked up and periodically cleaned out, usually at the end of the dry season. The earth from the bottom should be excavated until the ground water is reached, or until a sufficient depth has been attained, the work of excavation being stepped so that the slope of the bank will ultimately be 1 1 to the tank. The slope of the embankment should be

planted with grass above the highest water-level to prevent the washing of silt into the tank during heavy rains. The tank should be fenced and the water from it drawn off by a pump. No surface drainage or other pollution should be allowed to enter the tank. If these precautions are observed a tank may be quite a good village supply.

It will be noted that the object of most of the recommendations made in the preceding section has been to protect the water from pollution by human, and to a certain extent, animal excrement. By far the most important is human pollution. It is dangerous because water may be responsible for outbreaks of the following diseases. Typhoid fever and the paratyphoid fevers, diarrhoea, bacillary dysentery and cholera. schistosomiasis and guinea-worm infection. There is also a possibility that goitre may be due to the consumption of water contaminated by human excrement. In addition to those bacterial and helminthic diseases there are also diseases caused by certain chemicals dissolved in the water e.g. arsenical and lead poisoning, and diarrhoea due to an excessive quantity of mineral salts. The only group of these diseases or intoxications with which man is not concerned is the excessive mineral salt content. For all the others he himself is responsible. The measures which have already been described have as their main object the prevention of the pollution of natural waters by human beings, intentionally or otherwise. But such measures may not always be successful, the only water available may be from some grossly polluted source. How can such a polluted water be made safe?

Methods of Water Purification

In all purification processes the first thing which is done is to clarify the water. This may be done as follows.

(a) *Sedimentation Tanks*.—The water is led into large tanks or reservoirs where it is held for a considerable time. The suspended matters gradually sink to the bottom leaving the water clear. A considerable amount of purification takes place at the same time because in sinking to the bottom the particles of suspended matter carry with them large numbers of bacteria and confine them to the sediment. When sedimentation is complete the water is decanted off the sediment and passed on for purification treatment. The water of lakes owes its absence of tur-

bidity to the sedimentation which is always going on, cleanest water is that farthest from the inflow

(b) *Addition of Coagulants*—In big installations clay m great nuisance because it causes a turbidity which takes time to settle if left to itself and it gives an earthy taste water The water may be clarified and made tasteless by to it what is known as a *coagulant*. In this sense the word lant means something which when added to a mixture o stances causes in the mixture a change in the physical s the substances so that what were fluid or semi fluid b solid or semi-solid. The coagulant most commonly used in clarification is crude aluminium sulphate. This substance dissolved in alkaline water becomes converted into alum hydroxide, which appears as a jelly-like precipitate. Th cipitate entangles in its substance the fine particles o responsible for the turbidity and in sinking to the bottom container carries the clay with it, leaving a clear tasteless If the crude water does not have the required degree of alk lime or carbonate of soda are added to it before the alum.

In some parts of the East the inhabitants use a kind o to clarify the water they use. The nut is cut and the cut s is rubbed on the inner surface of the container After the has lain in the container for some time sedimentation occur the clear water is decanted for use.

Clarification is necessary before purification

(a) to remove turbidity

(b) to remove earthiness from the water

(c) to remove substances which might interfere with process of purification by means of chemicals thr rendering them inactive.

Purification of Water

A. *Boiling*—Boiling the water for a few minutes will kill pathogenic germs it may contain. *If one is thirsty and* quality of the water is unknown or doubtful, a cup of tea m from well-boiled water is the quickest way of getting a safe dr

B. *Filtration*.—Small scale. (a) Charcoal filters. These mentioned as a warning They are *quite* useless because t do not remove a sufficient number of bacteria from the wate make it safe.

(b) Filtering candles Such filters are hollow cylinders m

of fired Kieselguhr porcelain, or earthenware. One end is closed and the other is fitted by a water tight joint to a metal mount which carries a metal nozzle communicating with the interior of the filter The filter is mounted inside a metal or other suitable container in the form of an open cylinder one end of which is completely closed by the filter which is screwed into the cylinder in the upright position, having the filtering material projecting into the cylinder The water to be filtered is poured round the candle it gradually makes its way into the interior of the candle whence it appears through the nozzle in the metal mount. In its journey it has lost most of its bacteria, which have become entangled in the pores.

The Maintenance of Filtering Candles—The purifying action of the filtering candle is entirely mechanical. It does not kill the bacteria, and after a filter has been in use for some time it is found that the bacteria which have accumulated in the pores have penetrated the whole thickness of the candle and are appearing in the filtered water For this reason candles should be sterilised by boiling them for a quarter of an hour every three or four days. The candle is removed from the container It will be seen to be covered with a slimy substance which should be removed by scrubbing it with a toothbrush specially kept for the purpose. After it has been cleaned it should be totally immersed in cold water (an empty petrol tin is a suitable vessel for this) and brought slowly to the boil. It should be kept in the boiling water for quarter of an hour and then slowly allowed to cool. The efficacy of these filters depends upon the size of the pores in the material. Different materials have different-sized pores The smaller the pores the more efficient the filter but the slower the rate of filtration. Some filters have pores so fine that the water must be forced through them under pressure on account of the greatly increased friction which has to be overcome when the pores are fine. Friction also slows filtration in the candles which normally work under atmospheric pressure but in this case it is due to the clogging of the filter with bacteria and other suspended matter in the water The slowing of the rate of filtration in such a filter is a sign that it needs cleaning.

The boiling of filters exposes them to the risk of cracking and bacteria are so small that they may easily work through a crack invisible to the naked eye. The best way to test filters of this kind is to pump air through them while they are immersed

bidity to the sedimentation which is always going on. The cleanest water is that farthest from the inflow

(*b*) *Addition of Coagulants*.—In big installations clay may be a great nuisance because it causes a turbidity which takes a long time to settle if left to itself and it gives an earthy taste to the water. The water may be clarified and made tasteless by adding to it what is known as a *coagulant*. In this sense the word coagulant means something which when added to a mixture of substances causes in the mixture a change in the physical state of the substances so that what were fluid or semi-fluid become solid or semi-solid. The coagulant most commonly used in water clarification is crude aluminium sulphate. This substance when dissolved in alkaline water becomes converted into aluminium hydroxide, which appears as a jelly like precipitate. This precipitate *entangles in its substance the fine particles of clay* responsible for the turbidity and in sinking to the bottom of the container carries the clay with it, leaving a clear tasteless water. If the crude water does not have the required degree of *alkalinity* lime or carbonate of soda are added to it before the alum.

In some parts of the East the inhabitants use a kind of nut to clarify the water they use. The nut is cut and the cut surface is rubbed on the inner surface of the container. After the water has lain in the container for some time sedimentation occurs and the clear water is decanted for use.

Clarification is necessary before purification

(*a*) to remove turbidity
(*b*) to remove earthiness from the water
(*c*) to remove substances which might interfere with the process of purification by means of chemicals through rendering them inactive.

Purification of Water

A. *Boiling*.—Boiling the water for a few minutes will kill any pathogenic germs it may contain. If one is thirsty and the quality of the water is unknown or doubtful, a cup of tea made from well boiled water is the quickest way of getting a safe drink.

B. *Filtration*.—Small scale. (*a*) Charcoal filters. These are mentioned as a warning. They are quite useless because they do not remove a sufficient number of bacteria from the water to make it safe.

(*b*) Filtering candles. Such filters are hollow cylinders made

of fired kieselguhr porcelain or earthenware One end is closed and the other is fitted by a water tight joint to a metal mount which carries a metal nozzle communicating with the interior of the filter The filter is mounted inside a metal or other suitable container in the form of an open cylinder one end of which is completely closed by the filter which is screwed into the cylinder in the upright position having the filtering material projecting into the cylinder The water to be filtered is poured round the candle it gradually makes its way into the interior of the candle whence it appears through the nozzle in the metal mount. In its journey it has lost most of its bacteria, which have become entangled in the pores.

The Maintenance of Filtering Candles—The purifying action of the filtering candle is entirely mechanical It does not kill the bacteria, and after a filter has been in use for some time it is found that the bacteria which have accumulated in the pores have penetrated the whole thickness of the candle and are appearing in the filtered water For this reason candles should be sterilised by boiling them for a quarter of an hour every three or four days The candle is removed from the container It will be seen to be covered with a slimy substance which should be removed by scrubbing it with a toothbrush specially kept for the purpose. After it has been cleaned it should be totally immersed in cold water (an empty petrol tin is a suitable vessel for this) and brought slowly to the boil. It should be kept in the boiling water for quarter of an hour and then slowly allowed to cool. The efficacy of these filters depends upon the size of the pores in the material. Different materials have different-sized pores The smaller the pores the more efficient the filter but the slower the rate of filtration. Some filters have pores so fine that the water must be forced through them under pressure, on account of the greatly increased friction which has to be overcome when the pores are fine. Friction also slows filtration in the candles which normally work under atmospheric pressure, but in this case it is due to the clogging of the filter with bacteria and other suspended matter in the water The slowing of the rate of filtration in such a filter is a sign that it needs cleaning

The boiling of filters exposes them to the risk of cracking, and bacteria are so small that they may easily work through a crack invisible to the naked eye. The best way to test filters of this kind is to pump air through them while they are immersed

in water and watch how it appears on the outer side of the filter A bicycle pump attached to a piece of rubber tubing connected with the nozzle is all the apparatus needed. Sink the filter thus connected in water until it is completely submerged. Pump air into it slowly The air will appear on the outer side of the filter in the form of small bubbles spread evenly over the surface before they join together to make larger bubbles which rise through the water A stream of larger bubbles issuing from one part of the filter indicates that there is a dangerous crack there and the filter which shows this should be discarded.

All new filters should be tested in the same way before being brought into use.

Previous clarification of the water is essential for the proper working of all porcelain filters and filters of the same type. Unless the water is clarified the filter becomes choked much too often for convenience.

Filtration on a large scale.—A. *Slow sand filtration*. A filter of this kind is designed to give 1 square foot of surface for each 75 gallons of water filtered in twenty four hours. The essential part of the filter is the upper layer of fine sand. This is contained in large water-tight masonry tanks and is supported by gravel and boulders. The foundation of the filter is a layer of broken stone about a foot thick. On this foundation there is laid some 2 feet of graded gravel, the coarsest grade being laid first and the finest last. On the top of the gravel is spread a layer of some 3 feet of fine sand. The filter is filled from below with filtered water from a neighbouring filter and is submerged to a depth of about 18 inches to 2 feet. The water to be filtered is then ad mitted to the filter from the top and the filtered water discharged through a pipe at the bottom.

The action of the slow sand filter depends upon the development in the upper layers of sand of a mass of micro-organisms and plants known as *zooglea*. Round each grain of sand there develops this slimy material and it is this which removes the bacteria from the water as the water passes through it in its descent through the filter Since the layer consists of countless living organisms which require time to grow the filter does not attain its full efficiency for some days. The growth of the zooglea layer is known as the ripening of the filter and until the filter is ripe the water delivered by it is run to waste. In the course of time the zooglea layer becomes so dense that the rate

of filtration is greatly reduced. When the rate becomes reduced to a certain point the filter is emptied the zoogloea layer is removed together with the upper layers of the sand. The filter is then refilled from the bottom, allowed to ripen and brought into use again. After this has been done a number of times the depth of sand on the filter is considerably reduced New sand is then introduced to make the filter up to its original size and the process continued.

On account of the need of frequent cleaning slow sand filters are always provided in excess of the number actually required at any one time so as to allow the cleaning to be done in rotation without interrupting the supply

B. *Rapid sand filters or mechanical filters* Mechanical filters are of two kinds *Gravity filters* in which the water is forced through them by the head of water in the filter itself and *Pressure filters* which consist of closed cylinders in which water is forced through the sand under pressure obtained by pumping or from a head of water outside the filter In each kind, sand is the filtering medium and the actual filtration is done by an artificial film of jelly obtained by treating the water with alum in the way already described in clarification. Mechanical filters are much more rapid than slow sand filters when the difference in the area of the filtering layer of both is taken into account.

Other treatment—Water may be purified by *storage*. It is kept in large storage reservoirs exposed to the sun for a month or six weeks, after which time the pathogenic bacteria will all have died out, the water will have been clarified and will be fit for human use.

Treatment with Chemicals—Certain chemical substances are powerful disinfectants. Chlorine is one of these and since it is harmless to man in the dosage in which it is an effective disinfectant of water it is much used both on a small scale and a large, for the purification of water

The chlorine may be obtained from bleaching powder or it may be purchased in liquid form contained in large iron cylinders. When chlorine is issued in cylinders it is under a pressure of some 120 lb per square inch, at which pressure it is a liquid at ordinary atmospheric temperatures.

Bleaching powder is reputed to contain about 30 per cent. available chlorine It seldom does, and this is one of its disadvantages If bleaching powder is to be used for the sterilisation

of drinking water each batch should be analysed by a chemist shortly before use to find out how much available chlorine it contains and the dose adjusted accordingly. With exposure to air and sometimes even with mere storage under tropical conditions it rapidly deteriorates owing to the loss of chlorine. A more stable preparation of bleaching powder is on the market under the name of chlorosene, reputed to contain 30 per cent. available chlorine. It would be prudent to have this, too, chemically analysed before use.

The dose of chlorine needed for the sterilisation of water depends upon the number of bacteria in the crude water. Within certain limits the fewer the bacteria in the crude water the less chlorine will it be necessary to add to obtain satisfactory results. In practice the dose varies between 0·1 and 2 parts of chlorine per million parts of water by weight. A dosage of anything over 1 part per million may leave a taste in the water. This may be counteracted by adding to the chlorinated water potassium thiosulphate (photographic "hypo").

Chloramine.—When chlorine and ammonia are mixed in water new substances known as *chloramines* are produced. Chloramines are powerful disinfectants, much more powerful in solution even than chlorine, so that they may be used in doses which are quite imperceptible to the consumer. They have the further advantage of not being neutralised by organic matter. The chloramines are produced in water by the interaction of ammonium chloride and bleaching powder. The amount of ammonium chloride necessary to produce the required concentration of chloramine is dissolved in water and the solution is added to the water to be sterilised. The required dose of bleaching powder or chlorosene is then mixed with water and the mixture added to the water to be treated. The whole is then well mixed and allowed to stand for several hours.

The Permanganates.—Sodium and potassium permanganate may also be used for the sterilisation of water. They are more expensive than the other chemicals just described and are consequently only used on a small scale. They have been much used in cholera outbreaks for the disinfection of wells. The process is known as *pinking* the well on account of the colour imparted to the water by it. The pinking of a well is done as follows:

Calculate the amount of water in the well.

Weigh out the amount of permanganate which when added

to the well water will give a proportion of ½ oz. per 1 000 gallons of water in the well.

Dissolve the permanganate in water to make a concentrated solution and pour it into the well.

Stir up the water in the well so as to mix the concentrated solution thoroughly with the well water

Leave for twenty four hours.

Draw some of the water and examine it It should have a faint pink tinge if the dose has been right.

If the water is pink after twenty four hours, draw water from the well until it comes colourless. The well is now ready for use Should there be no pink tinge in the water after twenty four hours with this dosage (unlikely), double the dose and wait another twenty four hours before proceeding

Ice Factories

In the chapter on disinfection an account is given of what happens to a substance when energy is supplied to it in the form of heat. At the temperatures of the melting point and the boiling-point the application of heat makes no further difference to the temperature of the substance, the heat being entirely used up in changing the substance's physical state from solid to liquid or from liquid to gas.

Certain substances exist as gases at atmospheric temperature and pressure. We have seen that the temperature of the boiling-point can be raised by increasing the pressure on a liquid Similarly by increasing the pressure on a gas its condensation at ordinary atmospheric temperatures can be brought about and when it condenses and becomes a liquid it gives up its latent heat of vaporisation. If the liquid gas is allowed suddenly to expand by lowering the pressure on it, it evaporates quickly and absorbs its latent heat of vaporisation from its surroundings. It is on this principle that ice-making is conducted. A substance with a suitable boiling-point is enclosed in system of tubes. On part of the system there is a compressor which liquefies the gas. The liquid gas then passes under low pressure through a long tube immersed in brine which has a lower freezing point than water In its passage through this tube the gas evaporates and obtains its latent heat of vaporisation from the surrounding brine which consequently becomes cold. Vessels of water immersed in the brine have the water frozen after a time. Instead of being im

mersed in brine the pipes may be carried round an insulated room and the temperature of the room lowered to any desired degree by regulating the rate at which the gas enters the low-pressure pipe. The gas is pumped out of the low-pressure tube back into the compressor and the circulation continued. The substances used as refrigerants are carbon dioxide, ammonia, sulphur dioxide, ethyl chloride, methyl chloride and Freon.

The Hygiene of Ice making.—Ice may become contaminated at the factory or during delivery

Factory The most important thing is the water supply This must be above suspicion. No ice factory should be licensed unless the water to be used for the manufacture of the ice is pure and wholesome. The ice should be sampled at the factory for bacteriological examination from time to time.

The containers in which the water is frozen should be scrupulously clean. They should be scrubbed out weekly and sterilised by steaming The workmen should wear clean overalls during work and the same cleanliness as regards their hands and nails should be observed as in the case of other purveyors of foodstuff Adequate latrine and lavatory accommodation should be proprovided for the staff.

It is a counsel of perfection to recommend that no person who has suffered from typhoid fever or the paratyphoid fevers should gain employment in an ice factory

Spitting should be prohibited.

Delivery should be effected in closed vans.

Even in a well-conducted establishment pollution of the ice is always a possibility and it is dangerous because the temperature of the ice does not kill bacteria it merely suspends their activity The moral is that the inspector should advise his public never to keep foodstuffs in direct contact with ice, or to put ice into drinks to cool them. Foodstuffs and drinks should be cooled by being kept in an ice chest in which there are two separate compartments, one for the ice and another for the foods. Ice-boxes should always be stood on ant guards in the tropics since the cold has no deterrent effect upon ants.

Aerated Water Factories

Three processes go on in an aerated water factory (*a*) the cleaning of the bottles, (*b*) the preparation of syrups, (*c*) the bottling of the product. During any of these, nuisance or danger

to the public health may arise. Aerated water factories should therefore be licensed and registered.

It is preferable to have separate rooms for each of these processes. Where this cannot be done they may be carried out in separate parts of the same room, but kept entirely distinct from one another

The factory should be well lit and ventilated. All workers must wear scrupulously clean clothing while they are at work and special attention should be paid to the cleanliness of their hands. Many modern factories are now operated by machinery so that contact of the product with the hands of the workers is avoided, but there will be found in many tropical towns survivals of older apparatus to which most of this account will apply The floors should be of hard durable and smooth non-slip material. They should be capable of being flushed at the end of the day's work and this should be the routine procedure. Internal walls should be of non-absorbent material and should be washable They should be coated with white paint or lime wash.

Adequate lavatory accommodation and a supply of clean towels, soap and nailbrushes should be available for staff use. This and the latrine accommodation should be separate from the factory The latrines should be kept clean.

Bottle Washing.—Three tanks should be provided for washing the bottles. The tanks should be of galvanised or enamelled metal. The first of these is filled with pure water to which washing soda has been added in the proportion of half an ounce to the gallon of water On their return to the factory all bottles are immersed in this solution to soak. When the labels have floated off the bottles are transferred, after having been well scrubbed with a brush and drained, to the second tank which contains clean water pinked with potassium permanganate solution. The bottles are allowed to soak in this for some time. They are then well scrubbed internally with good bottle brushes, rinsed out and placed in tank No 3 which is filled with plain water Here they are again rinsed, inverted on a draining rack and allowed to dry

Syrup Room.—All syrups should be made on a table having a smooth, clean washable top Strainers should be washed daily in clean water boiled and kept in a dust-proof case or cupboard when not in use Syrup jars and bottles should be stored

in an ant-proof cupboard which is also fly proof When in use they should be kept covered over with clean muslin to keep off flies.

It is perhaps unnecessary to specify that the water supply to the factory must be above suspicion.

There are two types of bottle in use, the crown-capped bottle and the bottle made gastight by means of a glass ball fitting against a rubber ring The latter type of bottle is most insanitary and should be abolished. It is extremely difficult to clean on account of the ball and the shape of the neck, and dust is apt to collect in the space between the ball and the rim. This can be prevented by requiring the manufacturers to cover the rim of the bottle completely with a paper cover before the bottle is allowed to leave the factory These bottles are popular in the tropics because they can be opened without a special opener but their hygienic disadvantages are too great to be outweighed by this.

Crown caps are hygienic because the whole of the top of the bottle is covered over by the cap which consists of a metal cover lined with a thin disc of cork. Capping machines are needed for the insertion of the caps. There are two types, one fed with a supply of caps automatically the other requiring the insertion by hand of each cap. The automatic type is the most hygienic since it reduces the possibility of infection of the cork by contact with what may be a grossly infected left forefinger

CHAPTER XV

THE COLLECTION AND DISPOSAL OF SEWAGE

SEWAGE is dangerous because it may contain

(*a*) the eggs of intestinal helminths (*A duodenale N americanus S mansoni*)
(*b*) pathogenic protozoa and their cysts (*E histolytica Balantidium coli*)
(*c*) pathogenic bacteria (*Bact typhosum, Bact paratyphosum* A, B and C., *B dysenteriae B tuberculosis B leprae M melitensis*).

It should therefore be removed from the neighbourhood of human dwellings as soon as practicable to avoid those pathogenic organisms and helminths being spread by flies ants or cockroaches, or it should be disposed of on the premises in such a way as to render it harmless.

Means of Disposal in Rural Areas—Primitive man generally seems to care nothing about the disposal of his excreta, except to set apart some piece of ground near his hut which is used as the latrine, or he may defaecate in the nearest stream.

Defaecation on the surface of the ground favours the spread of

hookworm disease (direct contact with the naked feet)
tape worms (consumption by cattle and pigs)
typhoid fever (flies)
the dysenteries (amoebic and bacillary) (flies)
cholera (flies).

Defaecation into streams favour the spread of:

schistosomiasis (if the appropriate snail intermediate host is present)
typhoid fever
bacillary dysentery
cholera (by the infection of the water which may be used

pit. The cover is supported on two heavy battens along the f
and rear of the trench and extending beyond it for a distanc
2 feet at either end. The loose earth is mixed with heavy
spread over the sacking and beaten down (fly maggots).

The holes in the cover should be triangular in shape,
inches long, 14 inches behind and 4 inches in front. F
proof covers should be provided and kept accurately laid o
the holes so long as the latrine is not in use. A man should
specially detailed to see that this is done and to keep the fl
clean.

Disinfectants should not be used in a deep trench latr
because they may interfere with the natural digestion of t
excreta which the latrine is designed to effect.

When the contents of the latrine reach to within 3 feet of t
top the cover should be moved on to another trench previou
prepared, the sacking hanging inside folded back and the tren
carefully filled in with the earth (which should be kept dry
possible during the time the latrine is in use). The filling m
take a day or two because the earth tends to sink in the tren
contents. If the earth is dry and well broken up the tenden
for the sewage to rise to the surface is not so pronounced. Aft
the trench has been filled in with earth and well rammed dow
the ends of the sacking are brought over it and made to overla
along the middle line of the trench. They are given anoth
soaking in heavy oil and then covered over with well ramme
earth. The site of the latrine should then be clearly marked.

The Pit Latrine.—A useful type of latrine for rural areas in th
tropics.

Construction.—A rectangular pit 4 feet long, 2 feet wide an
not less than 6 feet deep the depth to be regulated by th
height of the ground water Round the top a masonry copin
raised at least 9 inches above the surface of the ground. Th
pit is covered with a wooden or reinforced concrete cover A
wooden cover is unsuitable because it is absorbent, difficult t
keep clean, liable to dry rot and to destruction by termites
The collapse of such a cover after a few years use, causing
the occupant to fall into the contents of his own pit latrine i
not calculated to stimulate the regular use of such pits in the
neighbourhood The cement cover though more expensive, is
therefore the better from every point of view In the middle of
the cover is a hole through which the user defæcates into the

latrine. The shape and size of the hole have already been given. The superstructures may be left to owners to provide from whatever materials are handy

Pit latrines should be situated at least 20 feet from a dwelling and at least 100 feet from any well.

Advantages of Pit Latrines

(*a*) Cheapness.
(*b*) Do not need skilled labour for their construction (with the exception of the slab)
(*c*) Easy to clean
(*d*) Easy to keep fly proof
(*e*) Prevent fouling of the surface of the soil and thus prevent ankylostomiasis.

Disadvantages

(*a*) Unsuitable in rocky areas.
(*b*) Require intelligent maintenance to prevent them from becoming serious fly and mosquito nuisances
(*c*) Retain an accumulation of fæcal material on the premises.
(*d*) It is practically impossible to prevent them from giving off an offensive smell but the deeper the pit the less the nuisance from flies and smell
(*e*) Unsuitable in crowded areas.
(*f*) May pollute the ground water

In areas where pit latrines are being installed the Sanitary Authority should have at its disposal an adequate number of noulds for the concrete slabs. It is much easier to transport the aw materials to the site of the latrine in charge of a skilled rorkman and have the slab made where it is to be installed than make the slabs at some central place and transport them over nsiderable distances. At villages and small groups of dwellings e supply for the whole may be made at one place convenient to

A good mixture for the construction of the slabs is cement easure, sand 2 measures, medium aggregate 5 measures. The ium aggregate is composed of 3 measures of 1½ inch broken es mixed with 1½ measures of ½-inch chippings. The stones neasured by passing them through sieves or screens of the red size. The slabs may be reinforced with galvanised iron netting or light iron rods.

The mixing of the concrete should be done on a wooden mixing platform. The required quantities of sand and aggregate are measured and mixed on the platform. The cement is sprinkled over the mixture which is then turned twice with the spade. After the second turning the mixture is watered with a watering-can fitted with a rose and again turned twice. It should be rammed into the moulds as soon after watering as possible. The mould should be left covered over with gunny bags soaked in water until the mixture has set sufficiently to allow the moulds to be removed. The slabs are kept wet with moistened gunny bags for a few days so that the mixture may set throughout. They are then fitted in place on the masonry foundation. The owner then constructs the superstructure to his latrine.

Pit latrines of this kind are known as shallow pit latrines. They require continual supervision. It is almost impossible to induce the users to keep the covers properly applied over the holes when not in use. They therefore swarm with flies, ants and cockroaches. In spite of their many disadvantages they are better than nothing at all because their use can be relied upon to bring hookworm disease under control and for this reason alone they represent an advance over conditions they are designed to replace.

There are two modifications of the pit latrine (*a*) the mound latrine and (*b*) the tube or bore hole latrine.

Mound Latrines.—A pit latrine adapted for localities in which the ground water is too near the surface of the soil to enable the ordinary pit latrine to be constructed. Its features are the same as the pit latrine and it has the same advantages and disadvantages with, in addition, a special liability to structural defects, not possible in the ordinary pit latrine.

The latrine is made as follows A pyramidal mound of earth, 6 feet square and 2 feet high is made and well rammed. Grass is encouraged to grow on the mound which should be left undisturbed to settle for some weeks. A hole 2 feet across the top and tapering somewhat towards the bottom is dug through the middle of the mound to a depth of 3 feet, or until ground water is met with. On top of the mound and over the pit is erected a light structure whose roof should have a single slope and should at all sides project beyond the margin of the mound. If the soil is unusually light a barrel or box with the base removed may line the pit. Such a privy gives eight months to a year's service.

Note the following points in the construction

(*a*) Instead of making a mound and digging through it, a pit is dug and an attempt made to build up around the mouth. This always collapses.

(*b*) The mound is insufficiently rammed and not given enough time to set collapse follows.

(*c*) The edges of privy roof do not extend beyond the limits of the mound and rain-drips wash the mound away

(*d*) Use of the privy as a bathroom results in the rapid filling of the pit with water and gives rise to a mosquito nuisance: the privy should not be used as a bathroom.

The Bore Hole or Tube Latrine —This type of latrine has been in use on the east coat of Africa for many years. It has been rediscovered fairly recently and is being recommended for use in many parts of the tropics.

The essential part of the latrine is a cylindrical hole 16 inches in diameter bored vertically into the earth to a depth of 20 feet. The boring is done by a special auger and in friable soils a lining of basket work made from split bamboo 20 feet long and 14½ to 15 inches in diameter lines the hole. If the soil is very soft the basket work is made a little longer so that when it is inserted in the hole it extends some inches above the surface of the ground.

The hole is covered with a cement slab 30 × 30 inches having in the middle a hole 9½ × 5½ inches. This slab forms the floor of the privy and the superstructure is erected upon it.

In areas liable to occasional flooding it is necessary to construct a cylinder of concrete round the upper part of the hole and to carry it above the ground level for a foot or more above flood water level. The projecting sleeve is then surrounded with rammed earth, brick, or masonry foundation, raised to the level of the sleeve and big enough to take the slab.

The Sanitary department keeps a number of boring augers and poles for the use of the public. Those are sent out in charge of a man who has experience in the use of them.

The following claims are made for this latrine

(*a*) It costs little to construct.

(*b*) It does not give off bad odours.

(*c*) Flies and mosquitoes will not breed in it.

(*d*) It prevents the spread of typhoid fever dysenteries, cholera and hookworm disease.

The mixing of the concrete should be done on a wooden mixing platform. The required quantities of sand and aggregate are measured and mixed on the platform. The cement is sprinkled over the mixture which is then turned twice with the spade. After the second turning the mixture is watered with a watering-can fitted with a rose and again turned twice. It should be rammed into the moulds as soon after watering as possible. The mould should be left covered over with gunny bags soaked in water until the mixture has set sufficiently to allow the moulds to be removed. The slabs are kept wet with moistened gunny bags for a few days so that the mixture may set throughout. They are then fitted in place on the masonry foundation. The owner then constructs the superstructure to his latrine.

Pit latrines of this kind are known as *shallow pit latrines*. They require continual supervision. It is almost impossible to induce the users to keep the covers properly applied over the holes when not in use. They therefore swarm with flies, ants and cockroaches. In spite of their many disadvantages they are better than nothing at all because their use can be relied upon to bring hookworm disease under control and for this reason alone they represent an advance over conditions they are designed to replace.

There are two modifications of the pit latrine (*a*) the mound latrine and (*b*) the tube or bore hole latrine.

Mound Latrines.—A pit latrine adapted for localities in which the ground water is too near the surface of the soil to enable the ordinary pit latrine to be constructed. Its features are the same as the pit latrine and it has the same advantages and disadvantages with, in addition, a special liability to structural defects, not possible in the ordinary pit latrine.

The latrine is made as follows A pyramidal mound of earth, 6 feet square and 2 feet high is made and well rammed. Grass is encouraged to grow on the mound which should be left undisturbed to settle for some weeks. A hole 2 feet across the top and tapering somewhat towards the bottom is dug through the middle of the mound to a depth of 3 feet, or until ground water is met with. On top of the mound and over the pit is erected a light structure whose roof should have a single slope and should at all sides project beyond the margin of the mound. If the soil is unusually light a barrel or box with the base removed may line the pit. Such a privy gives eight months to a year's service.

Note the following points in th[illegible] con[illegible]

(*a*) Instead of making a mound and d[illegible] a pit is dug and an attempt mad[illegible] to [illegible] th[illegible] mouth. This always co[illegible].

(*b*) The mound is insufficiently ram[illegible] d and [illegible] time to set [illegible] collapse follows

(*c*) The edges of privy roof do not ext[illegible] of the mound and rain-drops wa[illegible] th[illegible]

(*d*) Use of the privy as a bathroom results in the [illegible] of the pit with water and gives [illegible] to a [illegible] ance: the privy should not be used as a ba[illegible]

The Bore Hole or Tube Latrine.—This type of la[illegible] ha[illegible] been in use on the east coast of Africa for many years. It has been re discovered fairly recently and is being recommended f[illegible] in many parts of the tropics.

The essential part of the latrine is a cylindrical ho[illegible] 16 inches in diameter bored vertically into the earth to a depth of 20 feet. The boring is done by a special auger and in final [illegible] a lining of basket-work made from split bamboo 20 feet lon[illegible] and 14½ to 15 inches in diameter lines the hole. If the s[illegible] is very soft the basket work is made a little longer so that when it is inserted in the hole it extends some inches above the surface of the ground.

The hole is covered with a cement slab 30 [illegible] 30 in[illegible] having in the middle a hole 9¾ × 5¾ inches. This slab forms the floor of the privy and the superstructure is erected upon it.

In areas liable to occasional flooding it is necessary to construct a cylinder of concrete round the upper part of the hole and to carry it above the ground level for a foot or more above flood water level. The projecting sleeve is then surrounded with rammed earth, brick, or masonry foundation, raised to the level of the sleeve and big enough to take the slab.

The Sanitary department keeps a number of boring augers and poles for the use of the public. Those are sent out in charge of a man who has experience in the use of them.

The following claims are made for this latrine:

(*a*) It costs little to construct.
(*b*) It does not give off bad odours.
(*c*) Flies and mosquitoes will not breed in it.
(*d*) It prevents the spread of typhoid fever, dysenteries, cholera and hookworm disease.

Note.—The essential feature of this latrine is that it taps the subsoil water and becomes practically a leaching cesspit in which septic action takes place, resulting in the formation of a scum which is unsuitable for fly or mosquito breeding.

Disadvantage.—The smallness of the diameter renders occasional fouling of the upper walls of the latrine likely and may produce a latrine infection of hookworm by the migration of the larvæ from the upper part of the hole on to the surface of the concrete slab. This is apparently discounted by those who have experience of the working of such latrines, which appear to be an improvement on the shallow pit latrine in places where the nature of the soil and the configuration of the country allow of their establishment.

The Privy Midden.—The privy midden is occasionally met with in rural areas. It consists essentially of an enclosed space which may be either open or closed, over part of which is erected a superstructure on which the user sits or squats according to habit and defæcates into the space. The space is generally bounded by a masonry wall and has a masonry floor. The privy building is erected over the superstructure. If the space is roofed over and has water-tight floor and walls and if the dejecta are completely covered over with dry earth every time they are voided, such a latrine may be fairly inoffensive. When the midden fills up its contents are dug out and used as manure. Before being used as manure the contents should be stored for several months in a dry place so as to kill all hookworm larvæ that may be in them and to render them otherwise harmless (death of harmful bacteria).

The advantages of the privy midden are few. The cost of maintenance is considerable since it means the regular supply of dry earth. The result of this is that earth is seldom used and the whole privy becomes a most revolting nuisance, swarming with flies.

Bucket Latrine.—The bucket latrine is a privy in which the receptacle for the excreta is movable instead of being fixed as it is in the privy midden. It is the only practicable latrine in many parts of the world, because it can be installed at a comparatively moderate initial cost. This, of course, is offset by the fact that the maintenance charges are high on account of the need of maintaining a staff of labourers to remove the buckets and transport them from the houses to the place of disposal. The latrine

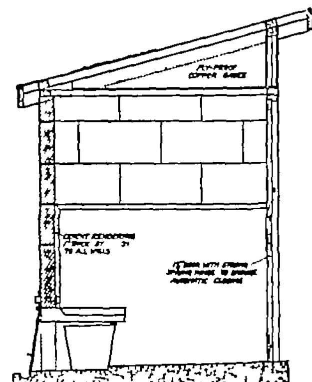


FIG. 38.—Type of fly-proof bucket latrine. Scale: [illegible] in. to 1 ft
(Courtesy of D.M.S.S., Kenya.)
(Kirk : Public Health Practice in the Tropics.)

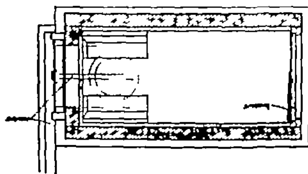


FIG. 39.—Plan of latrine shown in Fig. 38.
(Kirk : Public Health Practice in the Tropics.)

inspector is merely to see that the night soil coolies do their work properly The same holds good when a septic tank and erobic filter are in use. Here the problem has been dealt with by an engineer The inspector may however have to devise means by himself and this generally implies the purification of the sewage by contact with the earth.

Trenching—The following data must be taken into account

	European.	Indian.	African.
Average amount of solid excreta per head	6 oz.	16 oz.	12 oz.
" " urine per head	20 oz.	20 oz.	20 oz.
" ablution water per head	*Nil*	60 oz.	*Nil*

(These figures do not represent the quantities of excreta passed but the quantities likely to find their way into the buckets.) Quantities are fluid ounces.

The method of disposal of the sewage is to bury it in shallow trenches where the *action of micro-organisms in the earth* and in the sewage itself decompose it into a harmless substance.

The Trenching Ground—At least 500 yards from nearest house or well to the leeward of the village or town. Elevated and not liable to flooding Soil should be light. Heavy clayey soils are unsuitable. If one ground cannot be obtained of sufficient size to serve the needs a number may be chosen and used in rotation. Those lying at the higher levels should be reserved for use during the rainy season.

The area required can be calculated by reckoning that a trench 25 feet long, 2 feet broad and 1 foot deep filled to 3 inches will take 78 gallons of sewage. The actual area of land occupied by the sewage will be 50 square feet per 78 gallons. From this may be calculated the amount of land required for a year

The trenches should be parallel and 2½ feet apart. The trenching ground should have three times the calculated area since the method of working the ground is to trench it during one year allow it to remain fallow for a year and in the last year to cultivate it.

After a trenching ground has been in use for a number of years the trenches may be dug deeper and 6 inches of night soil poured into them. This will enable the same area to deal with double the quantity of sewage and give a reduction in the over

head costs, or alternatively it will enable the trenching ground to be reduced in size with the same financial effect.

In working the ground a sufficient number of trenches is

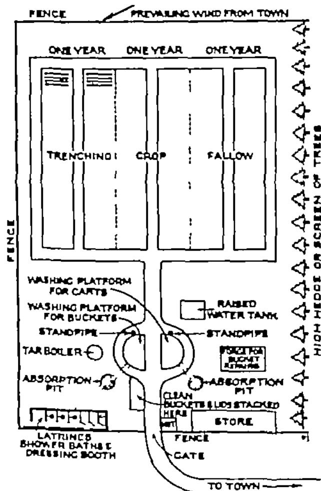


Fig 41 —Scheme of lay-out of trenching ground managed on three years rotation of crop

prepared daily for the reception of the following day's sewage. The sewage is poured into the trenches and covered over with the excavated earth which is well pulverised before being put over the sewage. After the ground has been worked over the spaces between the old trenches are then trenched so that by the

end of the year the whole area has been covered. It is then left fallow for a year a staff being kept to control weeds and bush, while the second of the three plots is being trenched. In the third year the first plot is cultivated, the second left fallow and the third trenched, and so on in regular sequence thereafter

The lay-out of the trenching ground is shown in Fig 41

Crops for human consumption should not be raised on a trenching ground. Suitable crops are sugar cane, jute, cattle fodder tobacco and mustard. The local cultivators will be able to advise the inspector regarding the best crops to be raised in that particular locality The above description envisages one large trenching ground. Local circumstances may oblige the inspector to modify the procedure by having a number of small grounds rather than one large one. The advantage of a number of smaller ones is that they may be situated at more convenient points and so diminish the time taken over the service, but they mean an increase in overhead charges and an increased number of nuisances. Every trenching ground is a nuisance of greater or less degree.

Pitting—The object of this is to store the sewage in large pits of convenient size until it is innocuous, when it is then sold to cultivators for manure. A variety of the pitting system is the Nasik system employed in India. Here the night soil is tipped into pits 2 to 3 feet deep 5 feet broad and of any convenient length. The pit, when nearly full, is covered over with town sweepings and the contents allowed gradually to dry out. Occasionally the gases evolved by the sewage rupture the covering layer The rupture is immediately covered over with fresh sweepings. After a year or more the contents of the pits have been reduced to a mould which is then sold to cultivators.

The danger here is that there is always a temptation to sell the product before it has become innocuous.

Septic Tank Treatment.—Sewage mixed with the top soil of the earth is broken down by the bacteria present in the soil into harmless substances. When sewage is mixed with water and is kept in a water tight tank putrefaction takes place, the sewage is split up into more primitive products much gas is given off during the decomposition of the sewage and a thick scum is formed on the surface. This is effected by a class of bacteria which live in atmospheres or liquids in which there is no oxygen

available, and they are therefore known as *anaerobic bacteria*. The final product in the tank is putrescible on contact with the air To break down its putrescible constituents into simple, inodorous and harmless products it must be acted upon by another class of bacteria, known as the *aerobic bacteria* because they require oxygen for their growth. The aerobic bacteria may be brought into contact with the septic tank affluent either by leading it into shallow drains containing small aggregate or clinker or it may be led over a contact-bed which is merely a structure permeable to air on which the aerobic bacteria can live. As the effluent is made to trickle slowly through the stones composing the contact bed it spreads itself in a very thin film on the stones, thus exposing an enormous surface to the air and providing a solution in which the aerobic bacteria flourish. These bacteria live on the substances contained in the effluent and in digesting it convert it into harmless salts and other substances which do not usually decompose further The effluent from a properly constructed and worked sewage contact bed should be clear and colourless and harmless to man or beast. It may safely be used for irrigation, for in their progress through the septic tank and contact bed pathogenic bacteria and the eggs of parasitic worms are killed. It sometimes happens in old contact beds that the effluent is not quite clear and contains small shreds of decomposable organic matter floating in it when this happens a small settling tank should be constructed on the drain leading from the contact bed to the irrigation channel.

In the septic tank and aerobic contact bed process for the purification of sewage the two processes, the anaerobic bacterial action and the aerobic bacterial action, take place separately in the soil they take place concurrently because the aerobic bacteria absorb the oxygen from the ground air and so create an atmosphere where the anaerobic bacteria can flourish.

Activated Sludge.—In the activated sludge process an attempt is made, by forcing air into the sewage in a septic tank, to cause both aerobic and anaerobic action to take place simultaneously in the tank. By this means the need for a costly aerobic contact bed is dispensed with. Activated sludge is merely the deposit in a septic tank which has been artificially aerated.

Septic tanks and activated sludge plants produce a quantity of residual matter which is sometimes very difficult to dispose of in a sanitary way because it holds water very tenaciously and

end of the year the whole area has been covered. It is then left fallow for a year a staff being kept to control weeds and bush, while the second of the three plots is being trenched. In the third year the first plot is cultivated, the second left fallow and the third trenched, and so on in regular sequence thereafter

The lay-out of the trenching ground is shown in Fig 41

Crops for human consumption should not be raised on a trenching ground. Suitable crops are sugar cane, jute, cattle fodder tobacco and mustard. The local cultivators will be able to advise the inspector regarding the best crops to be raised in that particular locality The above description envisages one large trenching ground. Local circumstances may oblige the inspector to modify the procedure by having a number of small grounds rather than one large one. The advantage of a number of smaller ones is that they may be situated at more convenient points and so diminish the time taken over the service, but they mean an increase in overhead charges and an increased number of nuisances. Every trenching ground is a nuisance of greater or less degree.

Pitting—The object of this is to store the sewage in large pits of convenient size until it is innocuous, when it is then sold to cultivators for manure. A variety of the pitting system is the Nasik system employed in India. Here the night soil is tipped into pits 2 to 3 feet deep 5 feet broad and of any convenient length. The pit, when nearly full, is covered over with town sweepings and the contents allowed gradually to dry out. Occasionally the gases evolved by the sewage rupture the covering layer The rupture is immediately covered over with fresh sweepings. After a year or more the contents of the pits have been reduced to a mould which is then sold to cultivators.

The danger here is that there is always a temptation to sell the product before it has become innocuous.

Septic Tank Treatment—Sewage mixed with the top soil of the earth is broken down by the bacteria present in the soil into harmless substances. When sewage is mixed with water and is kept in a water tight tank putrefaction takes place, the sewage is split up into more primitive products much gas is given off during the decomposition of the sewage and a thick scum is formed on the surface. This is effected by a class of bacteria which live in atmospheres or liquids in which there is no oxygen

available, and they are therefore known as *anaerobic bacteria*. The final product in the tank is putrescible on contact with the air To break down its putrescible constituents into simple, inodorous and harmless products it must be acted upon by another class of bacteria, known as the *aerobic bacteria* because they require oxygen for their growth. The aerobic bacteria may be brought into contact with the septic tank effluent either by leading it into shallow drains containing small aggregate or clinker or it may be led over a contact-bed which is merely a structure permeable to air on which the aerobic bacteria can live. As the effluent is made to trickle slowly through the stones composing the contact bed it spreads itself in a very thin film on the stones, thus exposing an enormous surface to the air and providing a solution in which the aerobic bacteria flourish. These bacteria live on the substances contained in the effluent and in digesting it convert it into harmless salts and other substances which do not usually decompose further The effluent from a properly constructed and worked sewage contact bed should be clear and colourless and harmless to man or beast. It may safely be used for irrigation, for in their progress through the septic tank and contact bed pathogenic bacteria and the eggs of parasitic worms are killed. It sometimes happens in old contact beds that the effluent is not quite clear and contains small shreds of decomposable organic matter floating in it when this happens a small settling tank should be constructed on the drain leading from the contact-bed to the irrigation channel.

In the septic tank and aerobic contact-bed process for the purification of sewage the two processes, the anaerobic bacterial action and the aerobic bacterial action, take place separately in the soil they take place concurrently because the aerobic bacteria absorb the oxygen from the ground air and so create an atmosphere where the anaerobic bacteria can flourish.

Activated Sludge —In the activated sludge process an attempt is made, by forcing air into the sewage in a septic tank, to cause both aerobic and anaerobic action to take place simultaneously in the tank. By this means the need for a costly aerobic contact bed is dispensed with. Activated sludge is merely the deposit in a septic tank which has been artificially aerated.

Septic tanks and activated sludge plants produce a quantity of residual matter which is sometimes very difficult to dispose of in a sanitary way because it holds water very tenaciously and

end of the year the whole area has been covered. It is then left fallow for a year a staff being kept to control weeds and bush, while the second of the three plots is being trenched. In the third year the first plot is cultivated, the second left fallow and the third trenched, and so on in regular sequence thereafter

The lay-out of the trenching ground is shown in Fig 41

Crops for human consumption should not be raised on a trenching ground. Suitable crops are sugar cane, jute, cattle fodder tobacco and mustard. The local cultivators will be able to advise the inspector regarding the best crops to be raised in that particular locality The above description envisages one large trenching ground. Local circumstances may oblige the inspector to modify the procedure by having a number of small grounds rather than one large one. The advantage of a number of smaller ones is that they may be situated at more convenient points and so diminish the time taken over the service, but they mean an increase in overhead charges and an increased number of nuisances. Every trenching ground is a nuisance of greater or less degree.

Pitting—The object of this is to store the sewage in large pits of convenient size until it is innocuous, when it is then sold to cultivators for manure. A variety of the pitting system is the Nasik system employed in India. Here the night soil is tipped into pits 2 to 3 feet deep, 5 feet broad and of any convenient length. The pit, when nearly full, is covered over with town sweepings and the contents allowed gradually to dry out. Occasionally the gases evolved by the sewage rupture the covering layer The rupture is immediately covered over with fresh sweepings. After a year or more the contents of the pits have been reduced to a mould which is then sold to cultivators.

The danger here is that there is always a temptation to sell the product before it has become innocuous.

Septic Tank Treatment.—Sewage mixed with the top soil of the earth is broken down by the bacteria present in the soil into harmless substances. When sewage is mixed with water and is kept in a water tight tank putrefaction takes place, the sewage is split up into more primitive products much gas is given off during the decomposition of the sewage and a thick scum is formed on the surface. This is effected by a class of bacteria which live in atmospheres or liquids in which there is no oxygen

available, and they are therefore known as *anaerobic bacteria* The final product in the tank is putrescible on contact with the air To break down its putrescible constituents into simple, inodorous and harmless products it must be acted upon by another class of bacteria, known as the *aerobic bacteria*, because they require oxygen for their growth. The aerobic bacteria may be brought into contact with the septic tank affluent either by leading it into shallow drains containing small aggregate or clinker or it may be led over a contact bed which is merely a structure permeable to air on which the aerobic bacteria can live As the effluent is made to trickle slowly through the stones composing the contact-bed it spreads itself in a very thin film on the stones, thus exposing an enormous surface to the air and providing a solution in which the aerobic bacteria flourish. These bacteria live on the substances contained in the effluent and in digesting it convert it into harmless salts and other substances which do not usually decompose further The effluent from a properly constructed and worked sewage contact bed should be clear and colourless and harmless to man or beast. It may safely be used for irrigation, for in their progress through the septic tank and contact-bed pathogenic bacteria and the eggs of parasitic worms are killed. It sometimes happens in old contact beds that the effluent is not quite clear and contains small shreds of decomposable organic matter floating in it when this happens a small settling tank should be constructed on the drain leading from the contact-bed to the irrigation channel.

In the septic tank and aerobic contact bed process for the purification of sewage the two processes, the anaerobic bacterial action and the aerobic bacterial action take place separately in the soil they take place concurrently because the aerobic bacteria absorb the oxygen from the ground air and so create an atmosphere where the anaerobic bacteria can flourish.

Activated Sludge—In the activated sludge process an attempt is made, by forcing air into the sewage in a septic tank, to cause both aerobic and anaerobic action to take place simultaneously in the tank. By this means the need for a costly aerobic contact bed is dispensed with. Activated sludge is merely the deposit in a septic tank which has been artificially aerated.

Septic tanks and activated sludge plants produce a quantity of residual matter which is sometimes very difficult to dispose of in a sanitary way because it holds water very tenaciously and

takes months to dry When satisfactory arrangements can be made for drying it it forms a good dressing for light soils.

Septic tank installations for small establishments do not need

Fig. 42.—Type of septic tank installation recommended by Crohurst for small establishments. (Kirk: *Public Health Practice in the Tropics.*)

contact beds. Surface irrigation or irrigation just beneath the surface is enough, or in places where the soil is suitable and there are piped water supplies it may be led into an absorption pit. A type of installation for small establishments is shown (Fig 42). The data are as follows The tank should measure 4 cubic feet per person, but the minimum size of tank is 6 feet long $3\frac{1}{2}$ feet wide and having a depth of sewage $4\frac{1}{2}$ feet.

The sewer line from the house to the tank should be 6-inch diameter pipes laid with tight joints and having a fall of not less than 1 foot in every 100 feet.

The effluent trenches should be of such a length as to provide 20 feet per person in coarse and sandy soils, and 100 or more feet per person in light soils.

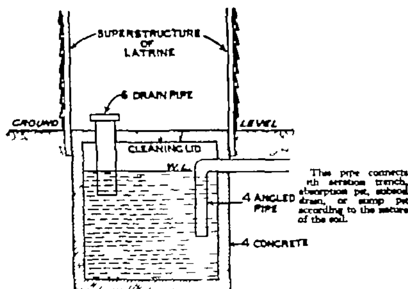


FIG. 43 —Type of modified aqua privy

One simple type of privy on the septic tank principle is a modification of the aqua privy which in turn, is a modification of the L.R.S. type. The principle is the same in all of them. Fig 43 shows its structure diagrammatically Before use the privy is filled with water and thereafter the daily addition of a small quantity of water is enough to keep the privy active. A manhole should be provided for the removal of the sludge which will accumulate in time. Since the effluent is very small in amount it may generally be disposed of by conducting it into a small absorption pit. The capacity of the privy should be calcu lated at the rate of 2½ cubic feet per user

This type of privy can be enlarged so as to make it a suitable means of sewage disposal for labour camps. In large installations the capacity may be 1½–2 cubic feet per user

At certain times these privies harbour large numbers of fly

larvæ. While one cannot generally prevent this, the insertion of a maggot barrier inside the rim of the drain pipe will prevent them from swarming all over the privy floor A suitable barrier is a 2 inch collar of sheet metal set into the rim at an angle of about 30 degrees from the vertical. Maggots attempting to pass the free edge fall back into the tank.

In rural areas where the occupants of a building desire to avail themselves of the convenience of a water-closet, and pit latrines are the means of sewage disposal in the neighbourhood, there is no objection to allow the water-closet drain to discharge into a pit latrine. The pit is covered over with a substantial cement cover set on a coping of brick and masonry and provided with a mosquito-proof manhole. It is by no means an ideal means of sewage disposal, but it is an improvement on the crude pit latrine because the fly cockroach and mosquito nuisance generally associated with pit latrines is in this way prevented.

CHAPTER XVI

THE COLLECTION AND DISPOSAL OF REFUSE

The refuse of a tropical community differs a good deal from that of one living in a temperate climate, the principal difference being that there is much more organic matter to be handled in the tropics than there is elsewhere and much less ash and cinders. The refuse is therefore more bulky and attractive to flies. On account of the greater heat of the tropics it decomposes more rapidly and soon becomes offensive.

The problem of the disposal of refuse is not very great in country villages. It becomes progressively more difficult and expensive of solution as the towns increase in size.

Arrangements should be made for the cleansing of public thoroughfares and for the removal of household and trade refuse as often as funds permit. In congested areas a twice-daily cleansing and removal may be necessary on the other hand residential areas may need the services of the scavenging staff only every other day

Refuse should not be allowed to accumulate in a town because such accumulations harbour rats (plague), tend to cause water nuisances (filariasis, dengue and other mosquito-borne infections) and cause a plague of flies (typhoid, the dysenteries and cholera), which find in decomposing organic refuse almost as attractive a breeding-place as they do in manure or human night soil. In dry climates accumulations of dry organic refuse are dangerous on account of fire.

The town-cleansing staff handle refuse from two sources the public thoroughfares and domestic and trade premises. The scavenging service should be organised to deal with these simultaneously In order to enable this to be done regulations or by laws must be enacted requiring householders to refrain from harbouring on their premises refuse of any kind, unless it be kept in containers of a prescribed type to place these containers, for the collection of their contents by the town-cleansing staff

either on the sidewalk or just inside their premises before a specified hour in the morning, and to cause the emptied containers to be removed from the sidewalk by a specified time.

Dust-bins —Dust-bins are the containers used for the retention of domestic refuse pending its collection by the scavenging staff. They should be of such a size that, when full, they can be easily lifted by one man (about 3 cubic feet). They should be constructed of smooth material, impervious to water and easily cleaned and they should be water tight. Galvanised iron forms a suitable material. The bins should be fitted with a lid fitting close over the top and not easily removable by dogs, cats, goats, or fowls. They must be strong enough to withstand hard usage, and yet light enough to be easily handled

It is a great convenience to have dust bins of a uniform type, but the cost of such bins is prohibitive to the poorer inhabitants of a town. In poor districts empty petrol or kerosene tins fitted with lids are adequate they answer all sanitary requirements they are cheap and easily procurable. If the Local Authority uses motor transport it can well afford to have dust-bins of this kind made from its own empty tins and sold to the public at a modest cost. All traders should be obliged to have the standard bin where such is prescribed.

The keeping of large animals should not be allowed in congested parts of towns, but frequently there are stables and cow sheds, the owners of which have vested rights and cannot be dislodged so long as they do not create a nuisance. The removal of the manure from such places should be done regularly and much the best arrangement is to leave a vehicle on the premises on which the manure can be stacked as it is taken from the stable, the load being removed as soon as the vehicle is full. This is much better than having the manure stacked in a midden to be removed at longer intervals, since it saves handling

Two classes of employees are recruited, "sweepers and lifters. The lifters should be of better physique than the sweepers since their work is to lift the dust bins and tip the contents into the refuse vehicles. The sweepers are provided with brooms and shovels. Their work is to clean the public thoroughfares, side gutters and drains, and deposit the refuse in the cart. All these employees are engaged on a daily basis, though for convenience they may be paid weekly fortnightly or monthly Attendances should be checked as a routine twice

daily at the morning muster and in the afternoon. Surprise musters should also be made from time to time.

In arranging the service the town is subdivided into a number of sections. In sectioning a town for any sanitary purpose it is useful to adhere to the municipal subdivision of wards so as to avoid duplication of the work of making a census. The sanitary sections may be more numerous than the wards, but so long as aggregates of sanitary sections correspond with the Municipal divisions, much labour will be saved in the direction indicated. Each sanitary section is placed in charge of an overseer provided with a number of gangs who is responsible for the cleansing of his section. Working with the overseer is a number of vehicles which transport to the place of disposal the refuse collected by the gangs. The labourers muster at the appointed place and time the roll is taken vacancies are filled and the tools are issued. They then form into gangs and proceed to work. When the day's work is finished they hand in their tools check off and are detailed for duty for the following day in sections which are worked over only periodically. The work of the overseer is to co-ordinate the transport vehicles with the activities of the sweepers and lifters, to see that the work is properly done and to prevent men absenting themselves from their task. He makes surprise checks of the gangs throughout the day and reports to the inspector who should control his work daily how the work is progressing.

The transport may be organised with mechanical haulage or animal. Mechanical haulage is much the more rapid and efficient. It is a good plan to have two types of vehicle, a large dust-cart and a small hand-cart which can be manhandled along the streets. If motor transport is used the covered trucks can be fitted with a coupling which will take a light two-wheeled trailer loaded with refuse. In Mauritius the town-cleansing transport is effected with such vehicles, as many as three trailers being towed by a loaded truck. The speeding up of the work by this means is remarkable. All vehicles used for the transport of refuse should be covered to prevent their contents from being blown all over the place.

In towns where there are tortuous and narrow lanes the provision of a number of large canvas sacks for the collection of the house refuse and its removal to the vehicles will be found useful. The bottom of these sacks may be reinforced with leather or wood.

either on the sidewalk or just inside their premises before a specified hour in the morning, and to cause the emptied containers to be removed from the sidewalk by a specified time.

Dust-bins.—Dust bins are the containers used for the retention of domestic refuse pending its collection by the scavenging staff. They should be of such a size that, when full, they can be easily lifted by one man (about 3 cubic feet) They should be constructed of smooth material, impervious to water and easily cleaned, and they should be water tight. Galvanised iron forms a suitable material. The bins should be fitted with a lid fitting close over the top and not easily removable by dogs, cats, goats, or fowls. They must be strong enough to withstand hard usage, and yet light enough to be easily handled.

It is a great convenience to have dust bins of a uniform type, but the cost of such bins is prohibitive to the poorer inhabitants of a town. In poor districts empty petrol or kerosene tins fitted with lids are adequate they answer all sanitary requirements they are cheap and easily procurable. If the Local Authority uses motor transport it can well afford to have dust-bins of this kind made from its own empty tins and sold to the public at a modest cost. All traders should be obliged to have the standard bin where such is prescribed.

The keeping of large animals should not be allowed in congested parts of towns, but frequently there are stables and cow sheds, the owners of which have vested rights and cannot be dislodged so long as they do not create a nuisance. The removal of the manure from such places should be done regularly and much the best arrangement is to leave a vehicle on the premises on which the manure can be stacked as it is taken from the stable, the load being removed as soon as the vehicle is full. This is much better than having the manure stacked in a midden to be removed at longer intervals, since it saves handling.

Two classes of employees are recruited, "sweepers" and lifters. The lifters should be of better physique than the sweepers since their work is to lift the dust bins and tip the contents into the refuse vehicles. The sweepers are provided with brooms and shovels. Their work is to clean the public thoroughfares, side gutters and drains, and deposit the refuse in the cart. All these employees are engaged on a daily basis, though for convenience they may be paid weekly fortnightly or monthly Attendances should be checked as a routine twice

daily at the morning muster and in the afternoon. Surprise musters should also be made from time to time.

In arranging the service the town is subdivided into a number of sections. In sectioning a town for any sanitary purpose it is useful to adhere to the municipal subdivision of wards so as to avoid duplication of the work of making a census. The sanitary sections may be more numerous than the wards but so long as aggregates of sanitary sections correspond with the Municipal divisions, much labour will be saved in the direction indicated. Each sanitary section is placed in charge of an overseer provided with a number of gangs who is responsible for the cleansing of his section. Working with the overseer is a number of vehicles which transport to the place of disposal the refuse collected by the gangs. The labourers muster at the appointed place and time the roll is taken, vacancies are filled and the tools are issued. They then form into gangs and proceed to work. When the day's work is finished they hand in their tools check off and are detailed for duty for the following day in sections which are worked over only periodically. The work of the overseer is to co-ordinate the transport vehicles with the activities of the sweepers and lifters, to see that the work is properly done and to prevent men absenting themselves from their task. He makes surprise checks of the gangs throughout the day and reports to the inspector who should control his work daily how the work is progressing.

The transport may be organised with mechanical haulage or animal. Mechanical haulage is much the more rapid and efficient. It is a good plan to have two types of vehicle, a large dust-cart and a small hand-cart which can be manhandled along the streets. If motor transport is used the covered trucks can be fitted with a coupling which will take a light two-wheeled trailer loaded with refuse. In Mauritius the town-cleansing transport is effected with such vehicles, as many as three trailers being towed by a loaded truck. The speeding up of the work by this means is remarkable. All vehicles used for the transport of refuse should be covered to prevent their contents from being blown all over the place.

In towns where there are tortuous and narrow lanes the provision of a number of large canvas sacks for the collection of the house refuse and its removal to the vehicles will be found useful. The bottom of these sacks may be reinforced with leather or wood.

either on the sidewalk or just inside their premises before a specified hour in the morning, and to cause the emptied containers to be removed from the sidewalk by a specified time.

Dust-bins.—Dust bins are the containers used for the retention of domestic refuse pending its collection by the scavenging staff. They should be of such a size that, when full, *they can be easily* lifted by one man (about 3 cubic feet). They should be *constructed of smooth material*, impervious to water and easily cleaned, and they should be water tight. Galvanised iron forms a suitable material. The bins should be fitted with a lid fitting close over the top and not easily removable by dogs, cats, goats, or fowls. They must be strong enough to withstand hard usage, and yet light enough to be easily handled.

It is a great convenience to have dust bins of a uniform type, but the cost of such bins is prohibitive to the poorer inhabitants of a town. In poor districts empty petrol or kerosene tins fitted *with lids are adequate*; *they answer all sanitary requirements*; they are cheap and easily procurable. If the Local Authority uses motor transport it can well afford to have dust-bins of this kind made from its own empty tins and sold to the public at a modest cost. All traders should be obliged to have the standard bin where such is prescribed.

The keeping of large animals should not be allowed in congested parts of towns, but frequently there are stables and cow sheds, the owners of which have vested rights and cannot be dislodged so long as they do not create a nuisance. The removal of the manure from such places should be done regularly and *much* the best arrangement is to leave a vehicle on the premises on which the manure can be stacked as it is taken from the stable, the *load being removed as soon as the vehicle is full*. This is much better than having the manure stacked in a midden *to be removed at longer intervals, since it saves handling*.

Two classes of employees are recruited, "sweepers" and lifters. The lifters should be of better physique than the sweepers since their work is to lift the dust-bins and tip the contents into the refuse vehicles. The sweepers are provided with brooms and shovels. Their work is to clean the public thoroughfares, side gutters and drains, and deposit the refuse in the cart. All these employees are engaged on a daily basis, though for convenience they may be paid weekly, fortnightly or monthly. Attendances should be checked as a routine twice

daily at the morning muster and in the afternoon. Surprise musters should also be made from time to time.

In arranging the service the town is subdivided into a number of sections. In sectioning a town for any sanitary purpose it is useful to adhere to the municipal subdivision of wards so as to avoid duplication of the work of making a census. The sanitary sections may be more numerous than the wards, but so long as aggregates of sanitary sections correspond with the Municipal divisions, much labour will be saved in the direction indicated. Each sanitary section is placed in charge of an overseer provided with a number of gangs who is responsible for the cleansing of his section. Working with the overseer is a number of vehicles which transport to the place of disposal the refuse collected by the gangs. The labourers muster at the appointed place and time the roll is taken, vacancies are filled and the tools are issued. They then form into gangs and proceed to work. When the day's work is finished they hand in their tools, check off and are detailed for duty for the following day in sections which are worked over only periodically. The work of the overseer is to co-ordinate the transport vehicles with the activities of the sweepers and lifters, to see that the work is properly done and to prevent men absenting themselves from their task. He makes surprise checks of the gangs throughout the day and reports to the inspector who should control his work daily how the work is progressing.

The transport may be organised with mechanical haulage or animal. Mechanical haulage is much the more rapid and efficient. It is a good plan to have two types of vehicle, a large dust-cart and a small hand-cart which can be manhandled along the streets. If motor transport is used the covered trucks can be fitted with a coupling which will take a light two-wheeled trailer loaded with refuse. In Mauritius the town-cleansing transport is effected with such vehicles, as many as three trailers being towed by a loaded truck. The speeding up of the work by this means is remarkable. All vehicles used for the transport of refuse should be covered to prevent their contents from being blown all over the place.

In towns where there are tortuous and narrow lanes the provision of a number of large canvas sacks for the collection of the house refuse and its removal to the vehicles will be found useful. The bottom of these sacks may be reinforced with leather or wood.

Transport Drivers' Books.—The transport drivers shou issued with day books ruled as under

Trip No.	From	To	Time of departure.	Initial	Time of arrival

Each driver should be issued with this book when he sta duty in the morning He is at the same time issued w measured quantity of motor spirit. He has standing or which are made known to all the overseers, not to move one place to another without having his time of departure arrival written in by the officers or overseers despatchin receiving him. Each officer must initial every entry mad him. At the end of the day's work the driver hands in to officer responsible for this work his book to be checked, the m age to be entered, and the petrol consumption to be wor out, after the motor spirit remaining in his tank has b measured. Such a system not only provides a complete rec of how the driver has been employed but shows at a gla whether the vehicle is efficient as regards its petrol consumpt

Mechanical transport will need someone to be made resp sible for the issue of stores, petrol and tyres, the accountancy the expenditure and the control of the drivers day books. mechanic will also be necessary to look after running repairs the changing of worn parts.

The drivers books will give an indication of the efficien of the vehicles only if the distances run each day are accurat measured on an accurate map or on the speedometer of t vehicle. In the latter case the speedometer should be check frequently over a measured distance and its error ascertaine Do not allow the clerk in charge to do what one bright labou saver did for a time with the writer He found it tedious measure the distances, so he assumed that each vehicle did 2 miles to the litre and calculated his distances on this basis fro the amount of spirit used every day

The Disposal of Town Refuse

The disposal of town refuse in Europe and in some larg cities of the East has become a highly specialised business o account of the salvage operations associated with it. In mos tropical towns there is not the same opportunity for the exercis

of ingenuity where salvage is concerned because there is little of value which can be recovered from the refuse of the small or moderate-sized tropical town and it is in this kind of place where the Sanitary Inspector finds that he has most to do with the cleansing of the town and the disposal of the refuse. By far the best way to dispose of the refuse of such a place is by controlled dumping There is always some large hollow in the neighbourhood liable to hold water and become a serious mosquito nuisance, and the filling of this by controlled dumping enables one to kill two birds with the one stone. Marshy areas, after having been drained, have had their level raised by this method, low lying areas near rivers or the sea have been filled in, and many tropical towns owe attractive parks and public gardens to this procedure.

Controlled dumping is the dumping of refuse carried out in such a way as to reduce the nuisance invariably associated with the method. Nuisance arises from smell combustion and the presence of flies and rats. Controlled dumping seeks to minimise such nuisances. As an illustration of the method we may describe the treatment of a large hollow perhaps a couple of acres in extent, of an average depth of 5 feet, having permanent collections of water in the lower parts and constituting mosquito nuisance of the worst kind.

The filling should begin at one part of the edge and should gradually extend over the whole area in a methodical manner Before the area is extended the filling should be carried to the ground-level and a top dressing spread over it strong enough to take a loaded lorry or light railway To begin with, the edge at which it is decided to begin work should be trimmed and made as nearly vertical as the soil will permit the soil from the trimming being kept apart for the top dressing of the refuse. It will not be enough, but it will always save the transport of so much earth or clinker from elsewhere. A road should then be constructed to the working edge and it should be made durable and passable even in wet weather The refuse is dumped into the hollow from the edge and is confined to a marked-out area of suitable size. A gang of labourers is maintained below to sort out the refuse roughly flatten tins, and bury paper and tins under the heavier vegetable refuse which bulks so large in the tropics. This prevents the papers from being blown all over the place by the wind. The refuse is well rammed and is gradually built

Transport Drivers Books—The transport drivers should be issued with day books ruled as under

Trip No.	From	To	Time of departure.	Initial.	Time of arrival.	Initial.	Miles run

Each driver should be issued with this book when he assumes duty in the morning He is at the same time issued with a measured quantity of motor spirit. He has standing orders, which are made known to all the overseers, not to move from one place to another without having his time of departure and arrival written in by the officers or overseers despatching or receiving him. Each officer must initial every entry made by him. At the end of the day's work the driver hands in to the officer responsible for this work his book to be checked, the mileage to be entered, and the petrol consumption to be worked out, after the motor spirit remaining in his tank has been measured. Such a system not only provides a complete record of how the driver has been employed but shows at a glance whether the vehicle is efficient as regards its petrol consumption.

Mechanical transport will need someone to be made responsible for the issue of stores, petrol and tyres, the accountancy of the expenditure and the control of the drivers day books. A mechanic will also be necessary to look after running repairs and the changing of worn parts.

The drivers books will give an indication of the efficiency of the vehicles only if the distances run each day are accurately measured on an accurate map or on the speedometer of the vehicle. In the latter case the speedometer should be checked frequently over a measured distance and its error ascertained. Do not allow the clerk in charge to do what one bright labour saver did for a time with the writer He found it tedious to measure the distances, so he assumed that each vehicle did 2½ miles to the litre and calculated his distances on this basis from the amount of spirit used every day

The Disposal of Town Refuse

The disposal of town refuse in Europe and in some large cities of the East has become a highly specialised business on account of the salvage operations associated with it. In most tropical towns there is not the same opportunity for the exercise

of ingenuity where salvage is concerned because there is little of value which can be recovered from the refuse of the small or moderate-sized tropical town, and it is in this kind of place where the Sanitary Inspector finds that he has most to do with the cleansing of the town and the disposal of the refuse. By far the best way to dispose of the refuse of such a place is by controlled dumping There is always some large hollow in the neighbourhood liable to hold water and become a serious mosquito nuisance, and the filling of this by controlled dumping enables one to kill two birds with the one stone. Marshy areas, after having been drained have had their level raised by this method, low lying areas near rivers or the sea have been filled in, and many tropical towns owe attractive parks and public gardens to this procedure

Controlled dumping is the dumping of refuse carried out in such a way as to reduce the nuisance invariably associated with the method. Nuisance arises from smell, combustion and the presence of flies and rats. Controlled dumping seeks to minimise such nuisances. As an illustration of the method we may describe the treatment of a large hollow perhaps a couple of acres in extent, of an average depth of 5 feet, having permanent collections of water in the lower parts and constituting mosquito nuisance of the worst kind.

The filling should begin at one part of the edge and should gradually extend over the whole area in a methodical manner Before the area is extended the filling should be carried to the ground-level and a top dressing spread over it strong enough to take a loaded lorry or light railway To begin with, the edge at which it is decided to begin work should be trimmed and made as nearly vertical as the soil will permit, the soil from the trimming being kept apart for the top dressing of the refuse. It will not be enough, but it will always save the transport of so much earth or clinker from elsewhere. A road should then be constructed to the working edge and it should be made durable and passable even in wet weather The refuse is dumped into the hollow from the edge and is confined to a marked-out area of suitable size. A gang of labourers is maintained below to sort out the refuse roughly flatten tins, and bury paper and tins under the heavier vegetable refuse which bulks so large in the tropics. This prevents the papers from being blown all over the place by the wind. The refuse is well rammed and is gradually built

up to ground level within the area marked out for it. When it reaches the ground level it is covered with a layer of earth or clinker 18 inches to 2 feet in thickness. The road or light rail way is advanced to the edge, which should be fairly vertical and another marked-out area filled in and so on until the whole has been filled Since the presence of standing water creates a bad smell nuisance when refuse is tipped into it, the water should be removed before dumping is begun. Flies can be reduced in numbers by detailing a man to go round with a hand-spray and spray the refuse with one of the insecticidal solutions mentioned on page 90

A watchman should be put on the dump to prevent dogs, goats and fowls from raking about in it.

A dump of this kind generates heat in its interior owing to the fermentation of its vegetable constituents, much in the same way as manure. Sometimes the heat is so great as to set fire to the refuse, which goes on smouldering for weeks. Eventually the whole of the organic matter is consumed and the fire dies out. When this happens subsidence takes place. Irregularities in the surface caused by the subsidence should be levelled out by rolling and adding more earth or clinker When clinker has been used a final top dressing of earth is given and grass is planted.

Controlled dumping is a good deal more expensive than merely tipping the refuse into a hollow and leaving it there. But the benefit to be gained by it is so much greater that the extra ex penditure is abundantly justifiable.

Building should not be allowed on land reclaimed in this way until sufficient time has elapsed for the consolidation of the whole area. This may take several years.

Incineration.—The method of controlled dumping is so gener ally applicable to practically any town except a big city that a detailed account of the several types of apparatus designed for the incineration of refuse seems superfluous. The large inciner ators, known usually as refuse destructors, having a capacity of many tons of refuse daily scarcely come into the Sanitary In spector's orbit at all. They are the concern of engineers and mechanics. Of the smaller there are many types, and they have their uses, the permanent type for the destruction of hospital or institutional refuse, and the portable for the destruction of refuse from infected premises. One of each type will be des-cribed.

An incinerator may be defined as an apparatus which enables refuse to be burnt with the minimum expenditure of fuel. The ideal incinerator should be self supporting There are two types of incinerator the open type in which the refuse is burnt in a chamber open to the air and the closed type in which there is a special combustion chamber which may or may not be fitted with a drying shelf or grid. The closed incinerator

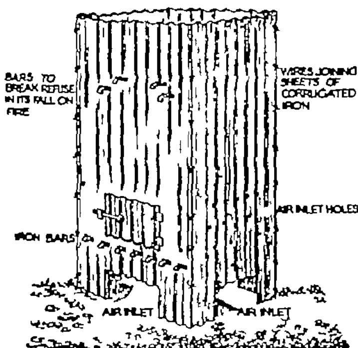


Fig. 45.—A corrugated iron incinerator
(Reproduced from the Army Manual of Hygiene and Sanitation, 1934 with the permission of the Controller of H.M. Stationery Office.)

requires a chimney of sufficient height to provide a good draught through the combustion chamber the open incinerator is its own chimney The closed incinerator is the more efficient type of the two, and the one to be described will not only burn refuse but will also, with careful manipulation, burn fæces. This is important with regard to hospitals.

There are other general points to be noted with regard to incinerators of any type. They should be mounted or stood upon a firm foundation and the ground round them should be flattened and rolled It is sometimes useful to have a walled

space, roofed over where the refuse may dry out before being burnt. A wall is necessary to prevent paper and rags from being blown about. Air is admitted from below and it is of the utmost importance that the air supply should be *plentiful*. The flues admitting the air are generally four in number set at right angles *to one another so as to catch whatever wind may be blowing*. In portable incinerators there may be only one flue and the apparatus should be set up so as to present the flue to the breeze. A raking door is necessary to prevent the flues clogging with ash. The ash should be raked out from time to time by the man in charge. A man should be in charge of the incinerator all the time it is working and his work should be frequently controlled. All incinerators should be situated on the leeward side of buildings.

The two incinerators described here have been evolved by the army. Within their limits they are effective. An open incinerator should not be expected to incinerate wet refuse or fæcal material. It is very efficient for the destruction of dry refuse.

The Corrugated Iron Incinerator (Fig. 45).—An open incinerator *constructed of four sheets of corrugated iron 4 feet 6 inches* high and the width of a sheet of corrugated iron. It has four air *inlets* each *12 inch × 8 inch and firebars are inserted through* holes cut 1 foot off the ground. The illustration shows the general appearance of the apparatus as set up.

The Bailleul Incinerator (Fig. 46).—Closed type. A square incinerator built of brick and lined with firebrick, erected on a concrete platform. The incinerator is fed through a door on the top and the consumption of fumes is assisted by an arched baffle wall. The dimensions are as follows for an institution of 1 000 beds. Width, 4 feet 6 inches. Length, 4 feet 3 inches. Height in front, 4 feet 6 inches, at back, 4 feet 9 inches. Concrete base, 5 feet × 6 feet × 4 ins. The top feed door is 2 feet square and consists of a sheet of sheet iron 2½ inches thick. The raking door measures 12 ins. × 9 ins. The grid is laid three courses above the level of the platform and an arched airway extends below it from front to back. The minimum height of the chimney is 15 feet.

The incineration of excreta.—Excreta can only be incinerated in a *closed* incinerator and if the following points are observed success should be obtained. (1) The excreta to be burnt should be mixed with a quantity of dry refuse or fuel. (2) The fire in the incinerator should have been well stoked and should be

burning fiercely (3) The mixture of fæces and refuse should be added to the incinerator a little at a time and only when the fire is burning fiercely (4) Between each addition of fæces a fresh charge of combustible material should be added to the fire

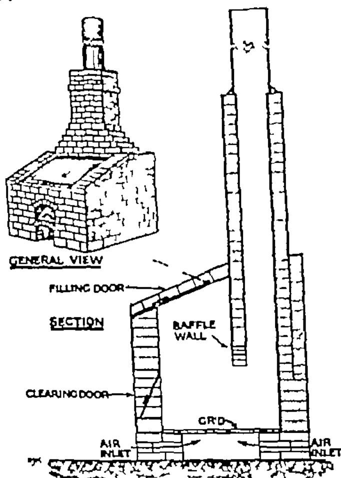


FIG. 46—The Bailleul Incinerator Type of incinerator designed to effect consumption of fumes.

The Disposal of Carcasses

In many tropical parts there are what may be termed natural agencies for the disposal of carcasses in the shape of jackals, crocodiles, sharks or other carnivorous creatures. In such places the disposal of a carcass presents little difficulty These natural agencies should not, however be allowed to operate if the disease

space, roofed over where the refuse may dry out before being burnt. A wall is necessary to prevent paper and rags from being blown about. Air is admitted from below and it is of the utmost importance that the air supply should be plentiful. The flues admitting the air are generally four in number set at right angles to one another so as to catch whatever wind may be blowing In portable incinerators there may be only one flue and the apparatus should be set up so as to present the flue to the breeze. A raking door is necessary to prevent the flues clogging with ash. The ash should be raked out from time to time by the man in charge. A man should be in charge of the incinerator all the time it is working and his work should be frequently controlled. All incinerators should be situated on the leeward side of buildings.

The two incinerators described here have been evolved by the army Within their limits they are effective. An open incinerator should not be expected to incinerate wet refuse or fæcal material. It is very efficient for the destruction of dry refuse.

The Corrugated Iron Incinerator (Fig 45).—An open incinerator constructed of four sheets of corrugated iron 4 feet 6 inches high and the width of a sheet of corrugated iron. It has four air inlets each 12 inch × 8 inch and firebars are inserted through holes cut 1 foot off the ground. The illustration shows the general appearance of the apparatus as set up

The Bailleul Incinerator (Fig 46).—Closed type. A square incinerator built of brick and lined with firebrick, erected on a concrete platform. The incinerator is fed through a door on the top and the consumption of fumes is assisted by an arched baffle wall. The dimensions are as follows for an institution of 1 000 beds Width, 4 feet 6 inches Length, 4 feet 3 inches Height in front, 4 feet 6 inches, at back, 4 feet 9 inches Concrete base, 5 feet × 6 feet × 4 ins. The top feed door is 2 feet square and consists of a sheet of sheet iron 2¼ inches thick. The raking door measures 12 ins. × 9 ins. The grid is laid three courses above the level of the platform and an arched airway extends below it from front to back. The minimum height of the chimney is 15 feet.

The incineration of excreta.—Excreta can only be incinerated in a closed incinerator and if the following points are observed success should be obtained (1) The excreta to be burnt should be mixed with a quantity of dry refuse or fuel. (2) The fire in the incinerator should have been well stoked and should be

burning fiercely (3) The mixture of fæces and refuse should be added to the incinerator a little at a time and only when the fire is burning fiercely (4) Between each addition of fæces a fresh charge of combustible material should be added to the fire

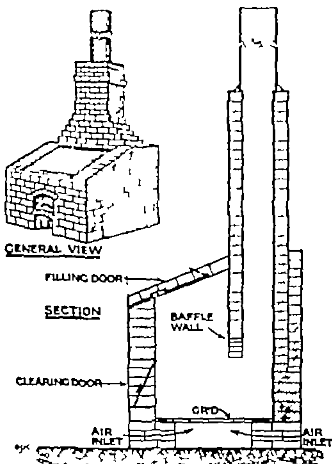


Fig 46 —The Bailleul Incinerator Type of incinerator designed to effect consumption of fumes.

The Disposal of Carcasses

In many tropical parts there are what may be termed natural agencies for the disposal of carcasses in the shape of jackals, crocodiles, sharks or other carnivorous creatures. In such places the disposal of a carcass presents little difficulty These natural agencies should not, however be allowed to operate if the disease

from which the animal has died is a communicable disease. Such carcasses should be buried. The best way to effect this is to disembowl the carcass and bury the internal organs separately If this is not done the carcass will swell and lift up or fissure the earth over it and a horrible fly nuisance will result. When the internal organs have been disposed of the interior of the carcass should be filled with dry refuse liberally sprinkled with kerosene oil and the whole covered over with a substantial heap of the same material. This is then set on fire, and when it has burnt out the carcass and the surrounding ground have been well disinfected. The body is dried out to a certain extent so that decomposition is slow if it does not proceed to mummification. The carcass is then buried. There is only one exception to this rule but it is a very important one. The body of an animal dead of anthrax should on no account be cut open but should be buried whole as soon as possible after death in a pit 10 feet deep containing as much quicklime as can be packed round the carcass. The object of not cutting the body is to prevent the anthrax bacilli from coming into contact with the air since it is only in contact with oxygen that they are able to form the resistant spores which enable them to live for long periods outside the animal body

CHAPTER XVII

LAUNDRIES

In the rural tropics the laundryman is often a private servant or he may wash for a small number of families. If he is a private servant he should be required to do his washing on the premises, unless the stream which he will suggest is known to be pure or at any rate not contaminated with gross pollution.

When a laundryman washes for a small number of families his sanitary shortcomings are that (1) members of his numerous family often sleep on the dirty clothes on his premises (2) he may wear his employers shirts or suits on festive occasions. The Sanitary Authority cannot do very much to prevent either breach of sanitary practice other than to oblige him to provide a special building for the clothes and to prohibit its use as a sleeping room. The dirty linen should be sorted and stored apart from the clean linen.

In towns bigger establishments are the rule, though one still finds the personal laundryman even in big cities. Where he occurs the Municipal Council should provide public wash-houses for his use, charging an appropriate fee for the accommodation

Establishments operating on a bigger scale than the personal laundryman should be worked on the same general principles as a disinfecting station, e.g there should be a clean side and a dirty side, and there should be as rigid a separation of the two as exists in a disinfecting station (Fig 20). The object of this is to prevent clothing which may have come from a case of infectious disease from coming into contact with clothing about to be issued. Apart from this there is little of public health importance in the administration of the laundry though certain precautions must be taken to safeguard the health of the workers.

The premises should be well ventilated and lighted. They should be capable of thorough cleansing, and should be kept scrupulously clean. The use of mechanical apparatus for the

washing of the clothes enables laundries to be worked with the minimum of danger to the workers since most operations are carried out in covered tanks and there is little steam allowed to escape into the air of the building

Sanitary arrangements, dressing-rooms and lavatories should be provided for the staff. When the staff is a mixed one separate closets and lavatories should be provided for men and women.

Laundries should be licensed and registered

CHAPTER XVIII

SCHOOLS

The inspector may be required to visit and report on a school The following points should be noted

Name of school. Whether government, aided, or private Name of manager or head teacher Number of pupils on the roll. Daily average attendance over the past month If average is low ascertain why

Pupils. Are they clean? Do they look healthy? Are there any obviously suffering from skin diseases, ringworm patchy baldness or any other disease? Why are such children allowed to attend? Are they having treatment for the condition?

School staff Are they clean and neatly dressed? Are their hands clean?

School premises. In good repair? Light? Well ventilated? Overcrowded? (Measure up some of the more crowded class rooms and ascertain how much floor space and cubic space there is for each pupil. There should be about 1 square feet per pupil floor space at least) Do the classrooms smell sweet or otherwise?

What are the school hours? What breaks do the pupils have during the day? Is there a playground? What size is it? (The usual size is 25 sq ft. per pupil in towns.)

Where do the children hang their hats and other clothing? Does each pupil have his own peg and is it well apart from the others?

Lavatory accommodation. Adequate? Clean? Are soap and nailbrushes provided for the use of the pupils?

Latrines. Type. Number Clean? Anybody in direct charge of them? Any evidence of fouling of the floor or the back of the latrine building?

Water supply Wholesome or suspect? Are drinking cups provided or is there a drinking fountain?

Refuse disposal. Is the school yard clean and tidy? Any rubbish lying about? Tins? Any mosquito nuisances? Rats?

Do hawkers of sweets and foodstuffs frequent the school? Are they licensed? Do they keep their goods covered from dust and flies?

washing of the clothes enables laundries to be worked with the minimum of danger to the workers since most operations are carried out in covered tanks and there is little steam allowed to escape into the air of the building

Sanitary arrangements, dressing-rooms and lavatories should be provided for the staff When the staff is a mixed one separate closets and lavatories should be provided for men and women.

Laundries should be licensed and registered.

CHAPTER XVIII

SCHOOLS

The inspector may be required to visit and report on a school The following points should be noted

Name of school. Whether government, aided, or private. Name of manager or head teacher Number of pupils on the roll. Daily average attendance over the past month. If average is low ascertain why

Pupils. Are they clean? Do they look healthy? Are there any obviously suffering from skin diseases, ringworm, patchy baldness or any other disease? Why are such children allowed to attend? Are they having treatment for the condition?

School staff. Are they clean and neatly dressed? Are their hands clean?

School premises. In good repair? Light? Well ventilated? Overcrowded? (Measure up some of the more crowded classrooms and ascertain how much floor space and cubic space there is for each pupil. There should be about 12 square feet per pupil floor space at least.) Do the classrooms smell sweet or otherwise?

What are the school hours? What breaks do the pupils have during the day? Is there a playground? What size is it? (The usual size is 25 sq ft. per pupil in towns.)

Where do the children hang their hats and other clothing? Does each pupil have his own peg and is it well apart from the others?

Lavatory accommodation. Adequate? Clean? Are soap and nailbrushes provided for the use of the pupils?

Latrines. Type. Number Clean? Anybody in direct charge of them? Any evidence of fouling of the floor or the back of the latrine building?

Water supply Wholesome or suspect? Are drinking cups provided or is there a drinking fountain?

Refuse disposal. Is the school yard clean and tidy? Any rubbish lying about? Tins? Any mosquito nuisances? Rats?

Do hawkers of sweets and foodstuffs frequent the school? Are they licensed? Do they keep their goods covered from dust and flies?

CHAPTER XIX

VILLAGE SANITATION

THE following notes integrate various references which have been made to this subject throughout the book.

Site—When a new village is being established the following should be borne in mind Elevated, or at least on well-drained soil. In close proximity to an ample supply of pure water At a distance from dangerous areas e.g swampy areas infested with anophelines or in Africa, fly country

Lay-out.—Remember the more compact the village, the easier it is to keep sanitary The best type of lay-out is to have an open space in the middle of the village, occupied by the market and bordered by public buildings and shops. Radiating from this central area are the roads. No market gardening should be allowed in the village. The area of cultivation should surround the village, not be mixed up with it. When the village is in the jungle the depth of the cultivated zone should not be less than 50 yards.

Guest House—The guest house should be on the outskirts of the village. Since its occupants will be coming from different parts of the country possibly bringing with them ticks, lice or bugs, the construction of the guest house should be sound and sanitary to prevent the establishment of vermin. A cement floor is essential. The internal construction should be simple and solid and be such as to prevent harbourage of vermin. A separate set of latrines and washhouses should be provided for both sexes.

Latrines—In areas where bore-hole latrines can be established it is preferable for every hut to have its own latrine. In other areas the question may arise as to whether individual latrines are more dangerous to the public health than communal latrines. This can only be settled in the light of local circumstances, but the following points should be noted

Feature.	Individual Latrines.	Communal Latrines.
Upkeep	Likely to be unsatisfactory	Likely to be satisfactory
Use	Likely to be used.	May not be used by women.
Danger to the public health.	Considerable, because there will be a large number of collections of night soil scattered throughout the village. The combined surface area of these considerable	Less. Number of collections of night soil fewer and not throughout the village. Combined surface area much less than individual pit latrines.
Construction.	Likely to be defective through lack of funds of the individual villager	The local authority is able to spend enough to ensure proper construction.
Structural maintenance.	Likely to be inadequate	Likely to be adequate

On these considerations the case for the communal latrines is overwhelming. The best type of communal latrine is the type of modified aqua privy described on p. 43. Several points should be noted with regard to communal latrines. (1) They should be located in inconspicuous places and yet be readily accessible from the dwellings. The latrine itself should be well screened from the public view by means of a deep hedge. (2) Separate compartments should provide privacy for the users. (3) Entirely separate latrines should be provided for women and they should be out of sight of those for men. (4) The latrines should be distinctly marked. Silhouette three-quarter life-size figures of a man or a woman in black on a white background are the best kind of sign in illiterate or polyglot countries. (5) The approaches as well as the latrine itself must be well lit at night. (6) Attendants should be in constant attendance on each latrine (*a*) to keep it clean and (*b*) to reassure the timid at night. It follows that the attendants should be persons who enjoy the confidence of the villagers. (7) The latrines should be so placed as to be readily accessible to householders.

Water Supply.—The best type of water supply in the village itself is a piped supply. If the water cannot be laid on to the

CHAPTER XIX

VILLAGE SANITATION

THE following notes integrate various references which have been made to this subject throughout the book.

Site.—When a new village is being established the following should be borne in mind Elevated, or at least on well-drained soil. In close proximity to an ample supply of pure water At a distance from dangerous areas e.g swampy areas infested with anophelines or in Africa, fly country

Lay-out.—Remember the more compact the village, the easier it is to keep sanitary The best type of lay-out is to have an open space in the middle of the village, occupied by the market and bordered by public buildings and shops. Radiating from this central area are the roads. No market gardening should be allowed in the village. The area of cultivation should surround the village, not be mixed up with it. When the village is in the jungle the depth of the cultivated zone should not be less than 50 yards

Guest House.—The guest house should be on the outskirts of the village. Since its occupants will be coming from different parts of the country possibly bringing with them ticks, lice or bugs, the construction of the guest house should be sound and sanitary to prevent the establishment of vermin. A cement floor is essential. The internal construction should be simple and solid and be such as to prevent harbourage of vermin. A separate set of latrines and washhouses should be provided for both sexes.

Latrines.—In areas where bore-hole latrines can be established it is preferable for every hut to have its own latrine. In other areas the question may arise as to whether individual latrines are more dangerous to the public health than communal latrines. This can only be settled in the light of local circumstances but the following points should be noted

Feature.	Individual Latrines	Communal Latrines.
Upkeep.	Likely to be unsatisfactory	Likely to be satisfactory
Use	Likely to be used	May not be used by women
Danger to the public health.	Considerable because there will be a large number of collections of night soil scattered throughout the village. The combined surface area of these considerable	Less. Number of collections of night soil fewer and not throughout the village. Combined surface area much less than individual pit latrines.
Construction.	Likely to be defective through lack of funds of the individual villager	The local authority is able to spend enough to ensure proper construction.
Structural maintenance.	Likely to be inadequate.	Likely to be adequate

On these considerations the case for the communal latrines is overwhelming The best type of communal latrine is the type of modified aqua privy described on p 43 Several points should be noted with regard to communal latrines. (1) They should be located in inconspicuous places and yet be readily accessible from the dwellings. The latrine itself should be well screened from the public view by means of a deep hedge. (2) Separate compartments should provide privacy for the users (3) Entirely separate latrines should be provided for women and they should be out of sight of those for men (4) The latrines should be distinctly marked. Silhouette three-quarter life size figures of a man or a woman in black on a white background are the best kind of sign in illiterate or polyglot countries. (5) The approaches as well as the latrine itself must be well lit at night. (6) Attendants should be in constant attendance on each latrine (a) to keep it clean and (b) to reassure the timid at night. It follows that the attendants should be persons who enjoy the confidence of the villagers. (7) The latrines should be so placed as to be readily accessible to householders.

Water Supply.—The best type of water supply in the village itself is a piped supply If the water cannot be laid on to the

houses the next best thing is to make it available through public standpipes. These had best discharge directly over a well-made absorption pit furnished with a well-constructed kerb. A public supply of this type is a much more satisfactory affair than a number of private wells. If the village is on a river or lake the measures mentioned on pp 225 226 should give a reasonable degree of safety If wells are the source it is better to have a small number of soundly constructed wells than a number of private wells which cannot be adequately supervised. If the supply is from tanks note the precautions mentioned on p 226.

Roads and Streets—The main roads should be wide and consist of a central part for wheeled traffic flanked by footpaths for pedestrians. The roads should be adequately drained, and the separation between the central portions and the footpaths may be planted with shade trees. If possible, the roads in the village should be oiled periodically to keep down the dust, if funds will not allow them to be tarred

Relation of Buildings to Plots—While compactness is desirable, overcrowding is not. The building plots should be laid out with reference to the type of house or hut usual in the district. The plot should be of sufficient area comfortably to hold the house and outbuildings such as bathrooms and latrine. In any case no main building should be allowed to approach nearer than 10 feet from the boundary of the plot. Such a rule will ensure adequate ventilation and lighting of the buildings if, at the same time the growth of dense vegetation is prevented.

Noxious Trades and Processes—Abattoirs, tanneries, stabling of domestic cattle and horses, the village destructor and trenching ground should all be on the outskirts of the village. It is not hygienic to have such establishments in close proximity to dwelling houses.

CHAPTER XX

MISCELLANEOUS DATA

Temperature To convert degrees F into degrees C. deduct 32, multiply by 5 and divide by 9

To convert degrees C. into degrees F multiply by 9, divide by 5 and add 32

PERCENTAGE SOLUTIONS

Quantity of Dry Measure required.

Percentage.	Parts.	In 1 fl. dram.	In 1 fl. dram.	In 1 pint.
	1 in	Grains.	Grams.	Grains.
1	100	0 55	4 38	87 50
2	50	1 10	8 75	175 00
2½	40	1 37	10 94	218 75
3	33 33	1 64	13 12	262 50
4	25	2 19	17 50	350 00
5	20	2 73	21 87	437 50
6	16 66	3 28	26 25	525 00
7	14 28	3 82	30 62	612 50
8	12 5	4 37	35 00	700 00
9	11 11	4 92	39 37	787 50
10	10	5 47	43 75	875 00

Quantity of Fluid Measure required.

Percentage.	In 1 fl. oz.	In 1 pint.			In 1 gallon.		
	Minims.	Oz.	dr.	min.	Oz.	dr.	min.
1	4 8	0	1	36	1	4	48
2	9 6	0	3	12	3	1	36
2½	12 0	0	4	0	4	0	0
3	14 4	0	4	48	4	6	24
4	19 2	0	6	24	6	3	1
5	24 0	1	0	0	8	0	0
6	28 8	1	1	36	9	4	45
7	33 6	1	3	12	11	1	36
8	38 4	1	4	48	12	6	24
9	43 2	1	6	24	14	3	12
10	48	2	0	0	16	0	0

The foregoing table is based on the *following*

1 grain of solid in 100 grain measures of water (at 16.7° C.) = 110 minims.

Fractions adjusted to the nearest hundredth

Metric System.

Measures of Length

1 Myriametre	Mm.	10,000	metres	= 6 2137 miles
1 Kilometre	Km.	1 000	"	= 0 6214 mile
1 Hectometre	Hm.	100		= 109 361 yards
1 Dekametre	Dm.	10	"	= 32 8084 feet
1 Metre	M.	1	"	= 39 370113 inches
1 Decimetre	dm.	0 1	"	= 3 937011
1 Centimetre	cm.	0 01	"	= 0 393701 "
1 Millimetre	mm.	0 001	"	= 0 039370
1 Micron	μ	0 000001	"	= 0 000039

Measures of Mass

1 Myriagramme	Mgm.	10 000	grammes	= 22 4061 pounds
1 Kilogramme	Kgm.	1 000	"	= 2 2406
1 Hectogramme	Hgm.	100		= 3 5274 Oz. Avoir
1 Dekagramme	Dgm.	10		= 154 3236 grains
1 Gramme	Gm.	*1*	"	= *15 4323* "
1 Decigramme	dgm.	0 1	"	= 1 54323 "
1 Centigramme	cgm.	0 01	"	= 0 15432
1 Milligramme	mgm.	0 001	"	= 0 01543

Measures of Capacity

1 Myrialitre	Ml.	10,000	litres	= 2199 76	Imp. gall.
1 Kilolitre	Kl.	1 000	"	= 219 976	" "
1 Hectolitre	Hl.	100	"	= 21 9976	" "
1 Dekalitre	Dl.	10	"	= 2 1997	" "
1 Litre	L.	1	"	= 35 196	Imp Fl. oz.
1 Decilitre	dl.	0 1		= 3 5196	" "
1 Centilitre	cl.	0 01	"	= 0 3519	" "
1 Millilitre *or* mil *or* Cubic centimetre cc.		0 001		= 0 0352 *or* 16 95 minims nearly	" " "

Imperial System.

Measures of Mass

1 Grain (gr)
1 Ounce (Avoir) oz. = 437 5 grains
1 Pound (Avoir). lb. = 16 oz. = 7,000 0 grains

Measures of Capacity

1 minim (*min.*) = *the* volume at 16 7° C. (62° F.) of 0 9114583 gr of water
1 Fluid Drachm (fl. dr.) = 60 min.
1 Fluid Ounce (fl. oz.) = 8 fl. dr
1 Pint = 20 fl. oz.

FACTORS FOR CONVERSION

	multiply by:
To convert grammes into grains	15 4323564
„ „ ounces, (Avoir.)	0 035274
ounces „ grammes	28 349
Kg into lbs	2 2406
grains into grammes	0 06479
cubic centimetres into Imperial Fluid ounces	35 196
Imperial fluid ounces into cubic centimetres	28 42
„ pints into litres	0 5679
„ metres into inches	39 370113
inches into metres	0 0254
cubic feet into gallons	6 22053
cubic feet into litres	28 318
„ litres into gallons	0 22
gallons into cubic feet	0 1605
„ gallons into litres	4 5459

SUPERFICIAL SPACE (AREA)

Area of Rectangle and Square = The length multiplied by the breadth.

Area of Rhombus or Rhomboid (in which the opposite sides are parallel) = The base multiplied by the perpendicular height.

Area of Trapezoid = Half the sum of the two parallel sides multiplied by the width

Area of Triangle = Half the product of base and height.

Area of regular polygon = The perimeter (sum of the sides) multiplied by half the perpendicular drawn from the centre to the middle point of any side.

Area of parabola = The base multiplied by two-thirds of the height.

Area of circle = Square of the diameter multiplied by 0·7854 or the square of the radius multiplied by 3 1416.

Area of Ellipse = The product of the long and short diameters multiplied by 0·7854

Area of segment of a circle = The cube of the height divided by twice the length of the chord added to two-thirds of the product of chord and height. *Note*.—When the segment is greater than a semicircle find the area of the circle and deduct the area of the smaller segment.

Area of sector of a circle = Half the product of the arc multiplied by the radius.

INDEX

Abattoirs, 193–199
Abattoir private, 198
— public, 194
Acclimatisation, 15
Acid, boric, as disinfectant, 154
— hydrochloric, in cholera, 154
— sulphuric, in cholera, 154
— sulphurous, as disinfectant, 151
Act, Infectious Diseases Notification, 34
Adaptability of human body 9
Ædes ægypti and dengue, 96
— and yellow fever 95 96
Alveoli, 30
Amœba, description of, 2, 3
— reproduction of, 3
Anæmia, in bookworm, 51
— in malaria, 92
Animal(s), domestic, and anthrax, 135
— — and mosquitoes, 100
— stabling of, in towns, 272
Animal, unicellular 2
Ankylostomiasis, general account, 51–56
Anopheles and malaria, 93
Anophelini, distinguishing features of, 86
Ant( ) and ice chests, 234
— and typhoid fever 36
Antenna, 78, 80, 82
Antguards and mosquitoes, 107
Anthrax, 135
— disposal of carcasses, 135
— farm animals and, 135
Antibodies, 11 13
— *production of, 13*
Anti-mosquito measures, 99–109
— — bed nets, 101
— — boots, mosquito 102
Anti-mosquito measures, clothing, 102
Anti-mosquito measures, canalisation of streams, 108
— — closing-over wells, 107
— — D.D T., 103 104
— — drainage, 109
— — filling in, *109*
— — fumigation, 102
— — Gammexane, 103 104
— — larvivorous fish, 106
— — mosquito-proof houses, *100*
— — removal of refuse, 107
— — spraying, 103
— — stabling of domestic animals, 100
— — traps, mosquito, 102
Anti-rabic treatment, when necessary 132
Antiseptics, 7
Anti-toxin, diphtheria, 69
— — preparation of, 13
A.N T U., 125
Anus, 19
Aorta, 22
Appendage insect, 77
Appendix, vermiform, 17
Arachnida, 76
Arista, 87
Armadillo, and Chagas disease 112
Arthropoda, 76
Atom, *140*
Auricle, 20

Baber's fly larva trap 209–211
Bacillus, 7
— lepræ, 74
Bacteria, 6
— *aerobic, 253*
— anærobic, 253
— reproduction of, 7
Bacterium typhosum, freezing and, 7
Bakehouse(s), underground, 201
— — — ( ), registration of 201

Disinfection of cutlery 158
— of excreta, 157 158
— of house, 151 158
— of leather goods 158
— of shaving-brushes, 159
— of skin, 158
— of sputum, 158
Disinfector improvised steam, 146
— portable steam, 147
Distillation 217
Dog(s) and Kala azar 113
— and Oriental sore, 114
— and rabies, 131
Doors, double mosquito-proof 101
Drainage, abattoir 197
— house, 166
Drains, subsoil, in malaria, 108
Droplet infection, 64
— — and diphtheria, 63
— — and lobar pneumonia, 71 72
— — and scarlet fever 70
— — and pneumonic plague, 73
— — and tuberculosis, 64
Dumping, controlled, 261
Duodenum, 17
Dust bins, 258
Dysentery amœbic, 46
— bacillary 45

Ecto-parasite, 40
Elephantiasis, 97
Emulsion, cresol, 123
— kerosene oil, 122
Endemic, definition of 42
Endo-parasites, 40
Endo-toxin, 12
Entamœba histolytica, 46
Enterozoa, definition, 5
Epidemic, definition of, 42
Epidemiology definition of, 42
Epipharynx, 80
Epizootic definition of, 120
Equipment dairy 212
Erythrocytes, 20
Espundia 115
Evaporation, latent heat of 141
Excreta, disinfection of, *158*
Excreta, incineration of, 264
Exoskeleton, 76

Factory (ies), aerated water 234
— ice 233
Fæces, definition of, 19
— and enteric fever 45
— and bookworm, 51
Fairs, and cholera, 48
Fats, 173
— energy value of, 174
Fertiliser fæces and cholera, 4
— — and typhoid fever 43
Fever(s), cerebro-spinal 69
— dengue, 96
— enteric, 42
— Malta (synonym for fever undulant), 48
— rat bite, 136
— relapsing, 116
— Rocky Mountain, 137
— scarlet, 70
— typhoid, 42
— — immunity following, 13
— — isolation for 36
— typhus, 118 137
— undulant, 48
— yellow 95
— — immunity following, 13
Fever yellow isolation of, 36
Fibrin, 20
Filaria bancrofti (W bancrofti), 97
Filariasis, 97
Filter(s), charcoal, 228
— gravity 231
— mechanical, 231
— pressure, 231
— rapid, sand, 231
— sewage, (contact bed), *253*
— slow sand, 230
Filtration of water 230
Flagellum, 5
Flea(s) blocked, in plague, *121*
— and plague, *41 121*
Flies and amœbic dysentery 47
— and cholera, 47
— and enteric fever *44*
— and refuse, 257
— and scarlet fever 70
Flies and typhoid fever 36
— *and tuberculosis, 64*
Floors, 164
Flukes, liver, 192

Fly house 87
— tsetse 88
Food, 172
Foodstuffs, chemical composition of, 176
— preservation of, 179
Formaldehyde gas in disinfection 153
Formalin, definition of, 157
Foundations, building, 163
Freezing as food preservative 181

Gammexane 89 103
Gauze, metal, anti-mosquito 101
Gland(s), lymph, 26
— — of food animals, 183
— parotid, 16
— salivary mosquito and malaria, 94
— — tsetse fly and sleeping sickness, 111
— sweat, 31
Glassware, disinfection of, 143 158
Glossina, 88
Glycogen, 16
Goats and undulant fever 48
Ground, trenching, 250
— — village, 272

Haemoglobin, 23
Halteres, 81
Heart, mechanism of, 20
Heat, as disinfectant, 142
— dry as disinfection, 142
— latent, 140
— moist, in disinfection, 142
Hendon disease, 71
Hides and anthrax, 135
Hookworm, and anaemia, 51
— disease, 51
— eggs, 51
— larvae, 52
— life-history of, 51
Host, definition of 40
— definitive, 43
— intermediate, 43
Host, reservoir in sleeping sickness, 110
House( ), common lodging, 167
— disinfection of, 158
House( ) dwelling, scheme f inspection of 170
— fumigation of 102 151
— guest 270
— let in lodgings, 167
— mosquito-proof 100
— screened, 100
Housing, 160
— and Kala azar 114
— and plague, 122
— and ticks, 119
Huts, back to-back, 16
Hydatids, 192
Hydrocyanic acid gas, 119
Hypopharynx, 80

Ice 234
Ileum, 17
Immunity 12
— active 14
— passive, 14
Incinerator 262
— Bailleul, 264
— corrugated iron, 264
Incubation period, 12
Inoculation, anti-rabic, 13
Insect, general description f, 77
Intestine large 17
— small, 17
Inventory in disinfection, 150
Irrigation and schistosomiasis, 59
Isolation, 35
Itch, ground, 53

Jackals and rabies, 131
Jejunum, 17
Juice, gastric, 16

Kala azar 113
— rehousing in, 114
Khana, 170
Kidney 30
Kissing and enteric fever 43

Labium, 77 80
Labour and lobar pneumonia, 71
Labrum, 80
Lairage 194
Latent heat, 140
Latrine( ), bore h 43
— bucket 44

Disinfection of cutlery 158
— of excreta, 157 158
— of house 151 158
— of leather goods, 158
— of shaving-brushes, 159
— of skin, 158
— of sputum, 158
Disinfector improvised steam, 146
— portable steam, 147
Distillation, 217
Dog(s) and Kala azar 113
— and Oriental sore, 114
— and rabies, 131
Doors, double, mosquito-proof 101
Drainage, abattoir 197
— house, 166
Drains, subsoil, in malaria, 108
Droplet infection, 64
— — and diphtheria, 63
— — and lobar pneumonia 71 72
— — and scarlet fever 70
— — and pneumonic plague 73
— — and tuberculosis, 64
Dumping, controlled, 261
Duodenum, 17
Dust-bins, 258
Dysentery amoebic, 46
— bacillary 45

Ecto-parasite, 40
Elephantiasis, 97
Emulsion, cresol, 123
— kerosene oil, 122
Endemic, definition of, 42
Endo-parasites, 40
Endo-toxin, 12
Entamoeba histolytica 46
Enterozoa, definition, 5
Epidemic, definition of, 42
Epidemiology definition of 42
Epipharynx, 80
Epizootic definition of, 120
Equipment, dairy 212
Erythrocytes, 20
Espundia, 115
Evaporation, latent heat of, 141
Excreta, disinfection of, 158
Excreta, incineration of, 264
Exoskeleton, 76

Factory (ies) aerated wa[ter]
— ice, 233
Faeces, definition of 19
— and enteric fever 45
— and hookworm, 51
Fairs, and cholera, 48
Fats, 173
— energy value of 174
Fertilizer faeces and chol[era]
— — and typhoid fever 4
Fever(s), cerebro-spinal (
— dengue, 96
— enteric, 42
— Malta (synonym f undulant), 48
— *rat-bite, 136*
— relapsing, 116
— Rocky Mountain, 137
— scarlet, 70
— typhoid, 42
— — immunity following, 1
— — isolation for 36
— typhus, 118 137
— undulant, 48
— yellow 95
— — immunity following 13
Fever yellow isolation of 36
Fibrin, 20
Filaria bancrofti (W bancrofti),
Filariasis, 97
Filter(s) charcoal, 228
— gravity 231
— mechanical, 231
— pressure, 231
— rapid sand, 231
— sewage (contact bed), 253
— slow sand, 230
Filtration of water 230
Flagellum, 5
Flea(s) blocked, in plague, 121
— and plague, 41 *121*
Flies and amoebic dysentery 47
— and cholera, 47
— and enteric fever 44
— and refuse, 257
— and scarlet fever 70
Flies and typhoid fever, 36
— and tuberculosis, 64
Floors, 164
Flukes, liver 192

Fly house, 87
— tsetse, 85
Food, 172
Foodstuffs, chemical composition of, 176
— preservation of, 179
Formaldehyde gas in disinfection 153
Formalin, definition of, 15
Foundations, building, 163
Freezing as food preservative 181

Gammexane, 89 103
Gauze, metal, anti-mosquito 101
Gland(s), lymph, 26
— — of food animals, 183
— parotid, 16
— salivary mosquito and malaria, 94
— — tsetse fly and sleeping sickness, 111
— sweat, 31
Glassware, disinfection of, 143 158
Glossina, 88
Glycogen, 16
Goats and undulant fever 48
Ground, trenching, 250
— — village, 272

Hæmoglobin, 23
Halteres, 81
Heart, mechanism of, 20
Heat, as disinfectant, 142
— dry as disinfection, 142
— latent, 140
— moist, in disinfection, 142
Hendon disease, 71
Hides and anthrax, 135
Hookworm, and anæmia 51
— disease, 51
— eggs, 51
— larvæ, 52
— life-history of, 51
Host, definition of 40
— definitive, 43
— intermediate, 43
Host, reservoir in sleeping sickness, 110
House( ), common lodging, 167
— disinfection of, 158
House( ) dwelling, scheme of inspection of 1 0
— fumigation of 102, 151
— guest, 270
— let in lodgings, 167
— mosquito-proof 100
— screened, 100
Housing, 160
— and Kala az 114
— and plague, 122
— and ticks, 119
Huts, back-to-back, 167
Hydatids, 192
Hydrocyanic acid gas 119
Hypopharynx, 80

Ice 234
Ileum, 17
Immunity 12
— active 14
— passive, 14
Incinerator 262
— Bailleul, 264
— corrugated iron, 264
Incubation period, 12
Inoculation, anti rabic, 132
Insect, general description of, 77
Intestine, large, 17
— small, 17
Inventory in disinfection, 150
Irrigation and schistosomiasis 59
Isolation, 35
Itch, ground, 53

Jackals and rabies, 131
Jejunum, 17
Juice gastric, 16

Kala azar 113
— rehousing in, 114
Khana, 170
Kidney 30
Kissing and enteric fever 43

Labium, 77 80
Labour and lobar pneumonia, 1
Labrum, 80
Lairage 194
Latent heat 140
Latrine( ) bore h d 43
— bucket, 44

Latrine(s) communal, 270
— in common lodging-houses, 169
— deep trench, 238
— fly-proofing of 247
— location of 166
— mound, 242
— pit, 240
— — polluting wells, 220
— *trench* 238
— tube, 243
— village 270
Laundries, 267
Leather goods, disinfection of, 158
Legislation, Food, 179
Leishmania donovani 113
Leishmaniasis, 112
Leprosy 74
Leucocytes, 20
Lids, bucket, night soil, 247
Life-history definition of, 41
Light, as *disinfectant* 139
Lime, as disinfectant, 157
— chlorinated as disinfectant, 157
Liver 17
— function of, 24
Louse (lice) 116
— and relapsing fever 41 116
— and Rocky Mountain fever 137
— and typhus fever 41 118 137
Lousing, method of, 117
Lymph, 19
— vaccine, 129
Lymphatics, 25

Malaria, 92
— anaemia due to, 94
— duration of infection in mosquito 94
Man, energy needs of, 174
Manure, fly breeding in, 209
— removal of, 258
Maps, in anti-mosquito work, 108
Maps, spot, 37
Marmot and plague, 120
Mask, pneumonic plague, 73
Materials, building, 161
"Measles" 61
Measles, immunity following 13
Measures, anti-mosquito 99
— anti sandfly 115
Meat, characteristics of sound
— — of unsound, 191
— inspection and tapeworm, 6
— marking apparatus, 195
— "measly" 61
Mediastinum, 27
Membrane, undulating, 4 110
Meningococcus, 69
Mercuric chloride as disinfect
157
— — disadvantages of, 155
Metamorphosis, 79
Metazoa, 5
Micturition, definition of, 31
Midden, privy 244
Milk, 203
— sampling of, for analysis, 20
— and diphtheria, 68
— and scarlet fever 70
— and tuberculosis, 65
— *and typhoid fever* 36 37
— and undulant fever 48
Milking, hygiene of, 211
Miracidium, 57
Molecules, 140
Mollusca, 5
Mosquito (*see* Anophelini
Culicini)
Mosquito boots, 102
Mosquito and *Filaria bancr*
97
— and refuse, 257
— and yellow fever 95
Mouse, multimammate and plag
120
Mucus, 11
Mumps, immunity following, 13
Musca, 87
Musca domestica, 87
Mutton, characteristics of sour
190
Muzzles and rabies, 132
Myriapoda, 77

Nemathelminthes, 5
Nematocera, 83
Net, bed, 101
— — in isolation, 36
— — and yellow fever 36, 96
Nucleus, 3

Observation, definition of 38
Œsophagus, 16
Offence, bacterial means of 11
Onychophora, 76
Oriental sore 114
Ornithodorus moubata, 77 119

Packing, manure t prevent fly breeding, 209
Palps, 80
Pancreas, 17
Pandemic, definition of 42
Parapet well, sanitary 222
Parasite, malaria, sexual reproduction of, 94
Parasitism, 40
Pasteurella pestis 72, 120
Pastures, and anthrax, 135
Periodicity in filariasis, 98
Permanganates, 232
Phlebotomus, 115
Pickling in preservation of food stuffs, 180
Pinking of wells, 232
Paté de Terre, composition of, 161
Plague, bubonic, 120
— fumigation in, 123
— and fleas, 121
— and gerbilles, 120
— and ground squirrels, 120
— and marmot, 120
— and multimammate mouse 120
— and rodents, 120
— pneumonic, 72
— — personal prophylaxis in, 73
— reservoirs of infection, 120
— rural, 126
Platyhelminthes, 5
Pleura, 27
Pneumonia, lobar 71
Pockets, air in disinfection, 145
Porifera, 5
Pork, characteristics of sound, 190
— measly 61 191
Powder bleaching, 231
Preservatives, food, chemical 162
Privy aqua, modified 255
Proboscis, insect, 77 83 87 88
Proglottis, 60
Prophylaxis, drug 95
Protein, 172
— energy value of 174
Protoplasm, 2
Protozoa, 5
Pseudopodia, 3
Ptyalin, 16
Pulse, arterial, 22
Pulses, germinating, 178
Pump, water 221

Quarantine, 38
— in rabies, 134

Rabies, 131
— laboratory diagnosis of, 133
Radiation, 139
Rate, birth, 35
— case mortality 35
— death, 35
— — corrected, 35
— — infectious diseases, 35
— — standard, 35
— infantile mortality 35
Rats and plague, 120
— and refuse, 257
Rectum, 19
Refuse collection and disposal of, 257
— disposal, controlled dumping, 261
— — incineration, 262
— and flies, 257
— and mosquitoes, 257
— and rats, 257
— tropical, composition of 257
Relapsing fever louse borne 116
— — tick borne 118
Re vaccination, 131
Rivers, sources of water supply 225
Roads, village 272
Roofing, 165
Room, condemned meat, in abattoir 197
— hanging, in abattoir 196
— milk 213
— offal, in abattoir 19⁻
— syrup, 235

Saliva, 16
— and diphtheria 63

Saliva, and rabies, 131 134
Salt(s) in dietary 178
— in food preservation, 180
Sampling, flour 202
— milk, 204
Sandfly 115
— and espundia, 115
— and Kala-azar 113
— and Oriental sore, 114
Sanitation, village, 270
Schick test, 69
Schistosomiasis, 56
Schools, inspection of 269
Scolex, 60
Screens, fly 45
Separator rain water 218
Serum, 20
— anti-bacterial, 14
— anti-toxic, 14
— immune, 13
Service scavenging, 257
Sewage, 236
— dangers from, 236
— disposal of, by activated sludge, 253
— — — by bore-hole latrine, 243
— — — by deep trench latrine, 238
— — — by incineration, 264
— — — by mound latrine, 242
— — — by pitting, 252
— — — by pit latrine, 240
— — — by septic tank, 252
— — — by tipping, 249
— — — by trenching, 250
— — — by trench latrines, 238
Shaving-brushes and anthrax, 135
— sterilisation of, 159
Shoes and hookworm, 35
Shop(s) Butchers 199
— — inspection of, 199
Site, building, 163
— village, 270
Skin, human, 31
— — disinfection of, 158
Slabs, pit latrine, 241
Sleeping sickness, 110
Sludge activated, 253
Smallpox, 127
Smallpox, immunity following,
— and vaccination, 127
— and variolation, 128
Snail, and schistosomiasis, 57
Soil and hookworm, 52
Solution, insecticide, 90 103 1
Spirilla, 7
Spirillum minus 116
Spitting in abattoirs, 196
— in common lodging-houses, 1
— in bakeries, 201
— and diphtheria in dairies, 63
— and tuberculosis, 64
Spleen, 23
Spore, bacterial, 8
Springs, protection of, 224
Sputum, disinfection of 158
— and enteric fever 43
— and tuberculosis, 64
Squirrel, ground, and plague, 120
Statistics, vital, 35
Steam, in disinfection, 143
— current, 144
— pentrative power of, 144
— pressure, 144
— streaming, 144
— superheated, 145
Stegomyia fasciata, 96
Sternum, 27
Stomach, 16
Stomoxys, 88
Stool(s), 19
— and typhoid fever 36
Storage, cold, 62
Storage, in water purification, 231
Stream, calculation of yield, 226
Stream, and typhoid fever 44
Sugar in preservation of food-stuffs, 180
Sulphur dioxide, 150
— — in food preservation, 182
— — liquefied, 151
— roll, 151
Surveillance, definition of, 38
System, alimentary 16
— circulatory 19
— double bucket, of sewage removal, 259–60
— lymphatic, 25
— lymphatic, of food animals, 187

System, Nasik, of sewage disposal, 252
— portal, 23
— renal, 30
— reparatory 26

Taenia echinococcus 192
Taenia saginata, 60
Taenia solium, 60
Tank(s), sedimentation, 227
— settling, 253
— water 226
Tapeworm infection, 60
Tartar emetic, 114
Taste, in water removal of, 228 232
Test, tuberculin, 65 214
Tetanus bacillus toxin of 1
Tick( ), 118
— and relapsing fever 41 118
— and typhus fevers, 137
Tins, food, inspection of, 181
Toxicity definition of 12
Toxin(s), 12
— diphtheria, 13 67
Toys and diphtheria, 68
Trachea, 29
Trades, noxious, 272
Transport, night soil, 249
— scavenging, 259
Traps, mosquito, 102
Trenching, 250
Treponema recurrentis 116
Triatoma megista, 112
Trichina spiralis 191
Trypanosomes, 110
Trypanosomiases, 110
Tsetse fly 88
— — and sleeping sickness, 110
Tuberculosis, 63
— bovine, 65
— closed, 64
— open, 64
— pulmonary 63

Undulant fever 48
Ureter 31
Urine in typhoid fever 36 43

Vaccination, 128
Vaccine, definition of 14
Vampire Bats and rabies 131
Variolation, in smallpox, 128
Veal, characteristics of sound, 190
— and tuberculosis, 65
Vegetables and hookworms, 55
— and typhoid fever 36 44
Ventilation, 167
Ventricle, 20
Verandah, 166
Vertebrata, 5
Vibrio cholerae 47
Village, sanitation of, 270
Villus, 17 24
Virulence, definition of, 12
Virus, filter passing, 8
Vitamins, 176

Wake( ) and enteric fever 44
— and plague, 126
Walls, 165
Water and water supplies, 216
— amount necessary 217
— and cholera, 47
— diseases borne by 227
— distilled, 217
— lake, characteristics of, 226
— methods of purification, 227
— — — boiling, 228
— — — chemicals, 231
— — — filtration, 228
— — — storage, 231
— rain, 217
— river characteristics of, 225
— and schistosomiasis, 56
— spring, characteristics of, 224
Water sullage, disposal of, 166
— supply village 71
— and typhoid fever 36
— well, characteristics of, 219
— — contamination of 220
Water wholesome requirements, 217
Water-closets, and mosquitoes 107
Well(s), 219
— artesian, 219
— calculation of yield, 2.3
— classification of, 219
— deep 220
— disinfection of, 232
— and enteric fever 44